This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 591

ANALYSES OF ROCKS AND MINERALS

FROM THE

LABORATORY OF THE UNITED STATES GEOLOGICAL SURVEY

1880 TO 1914

TABULATED BY

F. W. CLARKE, CHIEF CHEMIST

WASHINGTON
GOVERNMENT PRINTING OFFICE
1915

CONTENTS.

Analyses of igneous and crystalline rocks—Continued.

Lake Superior region—Continued

Analyses of igneous and crystalline rocks—Continued.

Colorado—Continued.

Analyses of igneous and crystalline rocks—Continued.

Oregon—Continued.

Analyses of clays, soils, etc.—Continued.

Analyses of minerals—Continued.

Analyses of minerals—Continued.

VII. Silicates—Continued.

Analyses of minerals—Continued.

VII. Silicates—Continued.

Analyses of minerals—Continued.

X. Borates—Continued.

Analyses of minerals—Continued.

XVI. Sulphates and tellurites—Continued.

ANALYSES OF ROCKS AND MINERALS FROM THE LABORATORY OF THE UNITED STATES GEOLOGICAL SURVEY, 1880-1914.

By F. W. CLARKE.

INTRODUCTION.

The present Geological Survey of the United States was organized in 1879. In 1880, in connection with the Colorado work, a chemical laboratory was established at Denver in charge of W. F. Hillebrand, with whom were associated Antony Guyard and, later, L. G. Eakins. In 1882 W. H. Melville was placed in charge of a second laboratory at San Francisco, and in the autumn of 1883 the central laboratory was started in Washington, with myself as chief chemist. In November, 1885, Dr. Hillebrand was transferred to Washington; early in 1888 he was followed by Mr. Eakins, and the Denver laboratory was discontinued. In the spring of 1890 Dr. Melville also was transferred to Washington, and since then the geochemical work of the Survey has been concentrated at headquarters. The special laboratories of the water-resources and technologic branches of the Survey are not included in this statement and their work is not represented in this bulletin.

Up to January 1, 1914, nearly 8,000 analyses have been made in the laboratory at Washington of rocks, minerals, ores, waters, sediments, coals, metals, and other substances with which geology has to do. Some hundreds of analyses were also made in the laboratories at Denver and San Francisco. A fair amount of research work upon mineralogical and analytical problems has also been done. In all of this work the following chemists have been employed: E. T. Allen, R. K. Bailey, Charles Catlett, T. M. Chatard, F. W. Clarke, L. G. Eakins, J. G. Fairchild, F. A. Gooch, Antony Guyard, W. B. Hicks, W. F. Hillebrand, W. F. Hunt, W. H. Melville, H. C. McNeil, Chase Palmer, R. B. Riggs, W. T. Schaller, E. A. Schneider, George Steiger, H. N. Stokes, E. C. Sullivan, William Valentine, R. C. Wells, W. C. Wheeler, and J. E. Whitfield. At present, January 1, 1914, eight of these chemists are employed in the Survey. Other officers of the Survey have been occupied more or less with chemical questions, but the men named in this list were connected directly with the laboratory. Some work for the chemical division has also been done by chemists not regularly on the rolls of the Survey, but their analyses, with the exception of a single group to be noted later, do not fall within the scope of this paper.

Quite naturally, on account of the activity of the petrographers, a dominant feature of the laboratory work has been the analysis of rocks. These have been studied in great numbers and in the most thorough way. The results have appeared in widely scattered publications, official reports, monographs, bulletins, American and foreign journals, and so on. The object of this bulletin is to bring together this valuable material, together with such bibliographic and petrographic data as seem to be necessary, in order to identify the specimens and to facilitate chemical discussion. Analyses of minerals have also been made in considerable numbers, and they are collected in the final section of this book. Some such analyses were made with direct reference to petrographic studies and therefore are cited in connection with the rocks to which they belong. Meteorites, of which 29 have been analyzed, are brought into the work on account of their petrographic relations, and the groups of clays and soils have been admitted because of the bearing of these substances on the study of slates and shales. The actual number of analyses given in the bulletin is as follows:

Igneous and crystalline rocks, including analyses of soluble or insoluble fractions, etc	1,407
Sandstones, cherts, and sinters	79
Carbonate rocks	315
Slates and shales	65
Clays, soils, etc	147
Meteorites and separations from them	62
Minerals	714
	2,789

It may be observed that the classification thus indicated has not been rigorously followed. The study of some sedimentary rocks has been so related to that of their igneous neighbors that the analyses are best tabulated together; but these exceptions are few, and all are properly noted. The heading "Igneous and crystalline rocks" has been used in the broadest and most liberal way, and doubtless many of the analyses given under it might properly be otherwise classified. In case of uncertainty, convenience has furnished the rule to follow.

Within each division of the analyses the classification chosen has been geographic. The petrographic grouping of the rocks would doubtless be best were petrographers agreed on it; but their differences are many, and the chemist will do well to avoid them. The geographic method, moreover, has some advantages of its own. It facilitates the study of areas, it simplifies the bibliographic references, and it brings together, in great measure, the work of each petrographer for whom analyses have been made. Thus, most of

Diller's work has been done in California, most of Cross's in Colorado, and most of Iddings's in the Yellowstone National Park, and the analyses of each are massed, and their discussion is practically uniform. As regards nomenclature, each rock has received the designation given it by its describer and no liberties have been taken. This plan may cause some lack of uniformity; but no other procedure seemed to be practicable. Whenever it was possible, however, I have inserted in italics the new names proposed by Cross, Iddings, Pirsson, and Washington in their classification of the igneous rocks. Most of these names were taken from Washington's great compilation of analyses published by the Survey in 1903.[1] Other names have been added by Washington and some by geologists for whom analyses were made. This addition, it is believed, will assist petrographers in their study of the material thus brought together.

The analyses vary in completeness. Among the sedimentary rocks especially partial analyses are common, but in the igneous group thoroughness is more general. In the early days of the chemical division many analyses were made in the older way, just as they are still made in many laboratories to-day—that is, only the main constituents, those having direct petrographic significance, were determined. In such analyses titanium, phosphorus, barium, strontium, chlorine, and other minor ingredients were ignored; and, although the results were in some respects satisfactory, they left much to be desired. Latterly greater completeness has been sought for, the work done has been much fuller, and the data obtained can be discussed with much closer approach to accuracy. The old form of "complete analysis" is to be discouraged. It leads too often to erroneous conclusions, and only the best modern methods of work and of statement should be tolerated. The fuller analyses, moreover, have brought some interesting points to light; titanium now appears to be one of the more abundant elements, and barium and strontium are found to be almost universally diffused in igneous rocks in perceptible quantities.

On general principles the analysis of a rock and its petrographic description should be two parts of the same investigation, matching each other completely. In practice, however, this rule does not always hold, and the departures from it are in two opposite directions. For example, an analysis of the older type says nothing of titanium and phosphorus, while the microscope reveals the presence of sphene and apatite. In this case the petrographer has been more thorough than the chemist. On the other hand, a full and perfect analysis may be given, accompanied by a petrographic description of the most general kind, in which only the main mineral constituents of the rock

---

[1] Professional Paper 14. Abbreviations in Professional Paper 28.

are noted. Here the analysis has been incompletely used and the petrographic discussion is defective. It is hoped that the publication of this material may lead to a clearer recognition of the mutuality which should exist between the chemical and the microscopic researches, and so bring, in the future, both lines of investigation more into harmony. Hitherto the chemist and the petrographer have worked too much apart, and each has too often misunderstood the purpose of the other. If the study of the thin section could always precede the analysis, the petrographic problems could be stated more clearly and the chemical evidence might be rendered much more pertinent and satisfactory.

During the preparation of this bulletin much assistance was rendered by the petrographers and geologists connected with the Survey, especially with reference to analyses hitherto unpublished. Credit has been given for all the data thus added. Twenty-eight analyses of rocks from Montana, made by or under the direction of Prof. L. V. Pirsson, of Yale University, in connection with regular Survey work, are included in the tabulations. With this exception all the analyses given were made in the Survey laboratories. To those executed in the laboratory at Washington "record numbers" are attached, which serve to identify them on the record books of the division of chemistry.

AVERAGE COMPOSITION OF ROCKS.

In a paper published some years ago,[1] on the relative abundance of the chemical elements, I computed the average composition of the primitive crust of the earth from 880 analyses of eruptive and crystalline rocks. Of these analyses only 207 were from the laboratories of the Survey, and 673 were collected from other American and foreign sources. A large proportion of them were incomplete, regarded from a modern point of view, yet the results obtained were fairly conclusive.

In Bulletin 148 a similar estimate was given, based upon 680 complete analyses found in the Survey records, plus some hundreds of determinations of silica, lime, and alkalies. Again, in Bulletin 168, a third estimate was presented, representing 830 complete analyses and some partial determinations, all made in the Survey laboratories. In 1899 Harker[2] published a computation covering 397 analyses of British rocks, and Washington[3] has worked out the average of 1,811 analyses given in his compilation. A more recent computation by Harker covers 536 British rocks, with results similar to those cited.

For the more important constituents of igneous rocks the five estimates mentioned above agree remarkably well, and yet they are not thoroughly comparable. Most of the 397 analyses discussed by Harker were incomplete, at least if considered from a modern stand-

---

[1] U. S. Geol. Survey Bull. 78, p. 34, 1891.

[2] Geol. Mag., 4th decade, vol. 6, p. 220.

[3] U. S. Geol. Survey Prof. Paper 14, p. 106, 1903.

point. In only 34 of them was titanium taken into account, and in only 55 is phosphorus mentioned. These omissions affect the percentages of other things and lessen the value of the computation very materially. Excluding manganese the five averages may be tabulated as follows. Minor constituents will be considered later:

	Clarke.			Harker.	Washington.
	First.	Second.	Third.		
SiO_2	58.59	59.77	59.71	58.75	58.239
Al_2O_3	15.04	15.38	15.41	15.64	15.796
Fe_2O_3	3.94	2.65	2.63	5.34	3.334
FeO	3.48	3.44	3.52	2.40	3.874
MgO	4.49	4.40	4.36	4.09	3.843
CaO	5.29	4.81	4.90	4.98	5.221
Na_2O	3.20	3.61	3.55	3.25	3.912
K_2O	2.90	2.83	2.80	2.74	3.161
H_2O at 100°	1.96	....	....	2.23	.363
H_2O above 100°		1.51	1.52		1.428
TiO_2	.55	.53	.60	.12	1.039
P_2O_5	.22	.21	.22	.02	.373
	99.66	99.14	99.22	99.56	100.583

Examination of the foregoing table shows several discrepancies, and one of them is in the variable treatment given to water. In two columns hygroscopic water does not appear; in two others total water is given; in Washington's estimate a discrimination has been made. If we reject the figures for water and recalculate the remaining constituents to 100 per cent, the comparison of estimates will assume the following form:

	Clarke.			Harker.	Washington.
	First.	Second.	Third.		
SiO_2	59.97	61.22	61.12	60.36	58.96
Al_2O_3	15.39	15.75	15.77	16.07	15.99
Fe_2O_3	4.03	2.71	2.69	5.48	3.37
FeO	3.56	3.53	3.60	2.46	3.93
MgO	4.60	4.51	4.46	4.20	3.89
CaO	5.41	4.93	5.02	5.12	5.28
Na_2O	3.28	3.69	3.63	3.34	3.96
K_2O	2.97	2.90	2.87	2.83	3.20
TiO_2	.56	.54	.61	.12	1.05
P_2O_5	.23	.22	.23	.02	.37
	100.00	100.00	100.00	100.00	100.00

Between Washington's computation and mine there is one fundamental difference—a difference of method. In my own calculations analyses were averaged together as if each one was complete—an assumption which is not justifiable. In some analyses minor constituents were not reported; in others they were determined with great care. The average of analyses varying in this way will obviously give too low a result for the rarer substances. Washington's policy was to consider the rock-forming elements separately, averaging each according to the actual number of determinations made, and thus to secure a truer group of estimates. For example, his average represents 1,811 determinations of Al_2O_3 and SiO_2, 1,625 of Fe_2O_3 and FeO, 1,139 of TiO_2, 955 of P_2O_5, and only 731 of MnO. The data thus utilized, however, coming from many laboratories and representing various methods of analysis, are evidently of very unequal value; and this consideration counts for something against the result finally obtained. I have therefore thought it desirable to repeat the computation, applying Washington's method to the determinations made in the laboratories of the Survey alone and using all the analyses, partial or complete, for my purpose. Every determination made upon an igneous rock has been thus utilized. If an element was definitely reported as absent, it has counted as zero in the averaging. To the statement of a "trace" I have arbitrarily assigned the value of 0.01 per cent. In this way I have obtained the following averages, which represent all of the data accumulated by the chemists of the Survey down to January 1, 1914.

Silica.—Average of 1,714 determinations, 60.86 per cent.

Alumina.—Average of 1,193 determinations, 15.17 per cent. In 93 additional determinations, TiO_2 and P_2O_5 were not separated; and these, therefore, are not included in the computation.

Ferric oxide.—1,242 determinations. Average 2.70 per cent.

Ferrous oxide.—1,238 determinations. Average, 3.52 per cent. In 38 analyses the oxides of iron were not separately determined, and in them the figure for iron is excluded from the calculation.

Magnesia.—1,328 determinations. Average, 3.88 per cent.

Lime.—1,564 determinations. Average, 4.93 per cent.

Soda.—1,632 determinations. Average, 3.44 per cent.

Potash.—1,624 determinations. Average, 3.05 per cent.

Water.—In 294 analyses, total water was determined; average, 1.80 per cent. In 912 analyses, water lost below 100°–110° was estimated; average, 0.48 per cent. In 959 analyses, water retained above 100°–110° gave an average of 1.45 per cent. Combining these data, the probable percentages are H_2O-, 0.47, and H_2O+, 1.48 per cent.

Titanic oxide.—1,140 determinations. Average 0.80 per cent.

Zirconia.—372 determinations. Average 0.023 per cent. These determinations were not made so generally as to give the average any great importance.

Phosphoric oxide.—1,136 determinations. Average, 0.29 per cent.

Baryta.—793 determinations. Average, 0.104 per cent.

Strontia.—649 determinations. Average 0.04 per cent.

Manganese oxide.—1,155 determinations. Average 0.10 per cent.

Carbon dioxide.—730 determinations. Average, 0.49 per cent. This is doubtless too high, for in many rocks carbon dioxide was not looked for. In 163 of the analyses in which it was reported the percentage was zero.

Lithia.—Commonly reported in traces, but often absent. Reckoning a "trace" as 0.01, the average of 581 analyses is 0.011 per cent. This is probably not far from a true estimate.

Nickel oxide.—299 determinations. Average, 0.026 per cent, which is probably too high.

Chromic oxide.—293 determinations. Average, 0.05 per cent. Probably too high.

Vanadium trioxide.—Only 102 determinations are reported; average, 0.026 per cent. Determinations too few to give this value any weight. The figure, however, is not without interest.[1]

Chlorine.—Determined or proved to be absent in 265 cases. Average, 0.064 per cent. Probably too high.

Fluorine.—Only determined or proved to be absent in 112 analyses. Average, 0.10 per cent, which is undoubtedly too high. An inferior limit, however, may be fixed with reference to P_2O_5. If we assume that to represent apatite, the equivalent amount of fluorine should be 0.026 per cent. The true average must be slightly higher.

Sulphur.—This element is reported in three forms—as S, as SO_3, and as FeS_2. Reported as S, 307 analyses give an average 0.044 per cent. As SO_3, 327 analyses give 0.11 per cent, equivalent to 0.044 per cent of S. In 149 analyses 0.68 per cent FeS_2 was found, equivalent to 0.36 of sulphur and 0.32 of Fe. The latter must be taken into account in estimating total iron. General average for sulphur, 0.104 per cent.

Now, if minor constituents are omitted and only those which appear in Washington's calculation are considered, his average and mine may be compared as follows:

	As given.		Reduced to 100 per cent.	
	Clarke.	Washington.	Clarke.	Washington.
SiO_2	60.86	58.239	60.47	57.78
Al_2O_3	15.17	15.796	15.07	15.67
Fe_2O_3	2.70	3.334	2.68	3.31
FeO	3.52	3.874	3.50	3.84
MgO	3.88	3.843	3.85	3.81
CaO	4.93	5.221	4.88	5.18
Na_2O	3.44	3.912	3.41	3.88
K_2O	3.05	3.161	3.03	3.13
H_2O-	.48	.363	.48	.36
H_2O+	1.45	1.428	1.44	1.42
TiO_2	.80	1.039	.80	1.03
P_2O_5	.29	.373	.29	.37
MnO	.10	.219	.10	.22
	100.67	100.802	100.00	100.00

One reason for the difference between my estimate and Washington's is not far to seek. The two columns of reduced averages are not strictly comparable, for one contains many partial analyses, and the other relates only to those which are nominally complete. For the interpretation of a subsilicic rock, which is mineralogically complex, a full analysis is usually necessary. For the simpler persilicic rocks, determinations of silica, lime, and alkalies are often sufficient for petrographic purposes. The partial analyses, therefore, represent mainly persilicic varieties, and their inclusion in the average tends to raise the percentage of silica and to lower that of magnesia or iron. But the persilicic rocks are undoubtedly more abundant than those of the other class, and so I am inclined to regard the higher figure for silica as more probable than the lower. If, however, we

---

[1] See Hillebrand, W. F., U. S. Geol. Survey Bull. 167, 1900, on the vanadium found in 57 rocks.

include all the minor constituents of rocks as given in my computation, the final result assumes the following form:

	Found.	Reduced to 100.		In elementary form.
SiO_2	60.86	59.88	O	47.09
Al_2O_3	15.17	14.92	Si	28.22
Fe_2O_3	2.70	2.66	Al	7.93
FeO	3.52	3.46	Fe	4.57
MgO	3.88	3.82	Mg	2.31
CaO	4.93	4.85	Ca	3.48
Na_2O	3.44	3.39	Na	2.52
K_2O	3.05	3.00	K	2.50
H_2O-	.48	.47	H	.16
H_2O+	1.45	1.43	Ti	.48
TiO_2	.80	.79	Zr	.017
ZrO_2	.023	.02	C	.131
CO_2	.49 –	.48	P	.121
P_2O_5	.29	.28	S	.101
S	.104	.10	Cl	.060
Cl	.064	.06	F	.026
F	.026	.03	Ba	.090
BaO	.104	.10	Sr	.034
SrO	.04	.04	Mn	.077
MnO	.10	.10	Ni	.023
NiO	.026–	.03–	Cr	.034
Cr_2O_3	.050–	.05–	V	.017
V_2O_3	.026	.03–	Li	.009
Li_2O	.011	.01		
	101.634	100.00		100.000

In the elementary column the iron reported in iron pyrites is included, but hygroscopic water is thrown out. The elements not included in the calculation represent minor corrections, to be applied whenever necessity may arise. For estimates of their probable amounts Vogt's papers may be consulted.[1] The percentages assigned to C, Zr, Cl, F, Ni, Cr, and V are nothing more than very rough approximations.

By a similar statistical process I have tried to ascertain something with regard to the relative abundance of the more important rock-forming minerals. Nearly 700 analyses of igneous rocks were studied, and the foregoing table of averages was also taken into account. For apatite, and for the titanium minerals titanite, ilmenite, and rutile the calculation was simple, but the other figures in the following table are approximative only:

Apatite	0.6
Titanium minerals	1.5
Quartz	12.0
Feldspars	59.5
Biotite	3.8
Hornblende and pyroxene	16.8
	94.2

The less frequent minerals make up the remaining 5.8 per cent. The computation, although it is by no means conclusive, is not without some significance. It is interesting to note that the average

---

[1] Zeitschr. prakt. Geologie, 1898, pp. 225, 314, 377, 413; and 1899, pp. 10, 274.

igneous rock has very nearly metasilicate ratios and is close to an andesite in composition. Its place in the new classification of rocks has been fully discussed by Washington.[1]

For computing the average composition of the sedimentary rocks existing analyses of individual samples are too few and too incomplete to yield any conclusions of value. Attempts have been made to partly use the data, as for example, by Joly,[2] and it seems probable, therefore, that better material will not be without interest or scientific value.

Nearly 20 years ago, at the request of G. K. Gilbert, a series of composite analyses of sedimentary rocks was made in this laboratory. Many samples were mixed into one uniform sample, from which, by a single analysis, an average composition was determined. The material was selected and the samples were prepared by Mr. Gilbert, assisted by G. W. Stose, and the analyses were made by H. N. Stokes. The data obtained may be tabulated as follows:

A. Composite analysis of 27 Mesozoic and Cenozoic shales. Each individual shale was taken in amount roughly proportional to the mass of the formation which it represented.

B. Composite analysis of 51 Paleozoic shales, weighted as in the former case.

C. General average of A and B, giving them, respectively, weights as 3 to 5. This average represents 78 rocks.

D. Composite analysis of 253 sandstones, about 1 gram of each being taken in preparing the average sample.

E. Composite analysis of 371 sandstones used for building purposes. Equal weights taken.

F. Composite analysis of 345 limestones, equal weights being taken.

G. Composite analysis of 498 limestones used for building purposes. Equal weights taken.

	A	B	C	D	E	F	G
SiO_2	55.43	60.15	58.38	78.66	84.86	5.19	14.09
TiO_2	.46	.76	.65	.25	.41	.06	.08
Al_2O_3	13.84	16.45	15.47	4.78	5.96	.81	1.75
Fe_2O_3	4.00	4.04	4.03	1.08	1.39	.54	.77
FeO	1.74	2.90	2.46	.30	.84	Undet.	Undet.
MnO	Trace.	Trace.	Trace.	Trace.	Trace.	.05	.03
CaO	5.96	1.41	3.12	5.52	1.05	42.61	40.60
SrO	None.	None.	None.	Trace.	None.	None.	None.
BaO	.06	.04	.05	.05	.01	None.	None.
MgO	2.67	2.32	2.45	1.17	.52	7.90	4.49
K_2O	2.67	3.60	3.25	1.32	1.16	.33	.58
Na_2O	1.80	1.01	1.31	.45	.76	.05	.62
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
H_2O at 110°	2.11	.89	1.34	.31	.27	.21	.30
H_2O above 110°	3.45	3.82	3.68	[a]1.33	[a]1.47	[b].56	[b].88
P_2O_5	.20	.15	.17	.08	.06	.04	.42
CO_2	4.62	1.46	2.64	5.04	1.01	41.58	35.58
S	....	....	....	....	....	.09	.07
SO_3	.78	.58	.65	.07	.09	.05	.07
Cl	....	....	....	Trace.	Trace.	.02	.01
Carbon [b]	.69	.88	.81	....	....	....	....
	100.48	100.46	100.46	100.41	99.86	100.09	100.34

[a] Includes organic matter. [b] Of organic origin.

---

[1] U. S. Geol. Survey, Prof. Paper 14, 1903.

[2] An estimate of the geological age of the earth: Royal Dublin Soc., Sci. Trans., vol. 7, p. 23, 1899.

These analyses may be used for a variety of purposes. For example, they can help in tracing the change from an average igneous rock to an average sediment. They suggest something as to the characteristic features which distinguish a good building stone from other limestones and sandstones. They are applicable to the discussion of a variety of large theoretical problems like that chosen by Prof. Joly.[1] These considerations alone justify their publication here.

ABBREVIATIONS USED.

Of the abbreviations used for bibliographic reference only five need explanation, and they refer to the official publications of the Survey—"Ann." for Annual Report, "Mon." for Monograph, "Bull." for Bulletin, "P. P." for Professional Paper, and "Folio" for Folio of the Geologic Atlas. The others relate to well-known journals and are familiar to all geologists. The letters P. R. C., following the description of a rock, refer to the petrographic reference collection of the Survey and are followed by the number assigned to the rock in that series. In the tables of analyses the symbols H_2O- and H_2O+ indicate respectively the water lost at or near 100°, and that expelled at higher temperatures.

For the information of readers in foreign countries the abbreviations used for names of States of the United States are explained below:

Ala., Alabama.
Ariz., Arizona.
Ark., Arkansas.
Cal., California.
Colo., Colorado.
Conn., Connecticut.
Del., Delaware.
D. C., District of Columbia.
Fla., Florida.
Ga., Georgia.
Ill., Illinois.
Ind., Indiana.
Kans., Kansas.
Ky., Kentucky.
La., Louisiana.
Md., Maryland.
Mass., Massachusetts.
Mich., Michigan.
Minn., Minnesota.
Miss., Mississippi.
Mo., Missouri.
Mont., Montana.
Nebr., Nebraska.
Nev., Nevada.
N. H., New Hampshire.
N. J., New Jersey.
N. Mex., New Mexico.
N. Y., New York.
N. C., North Carolina.
N. Dak., North Dakota.
Okla., Oklahoma.
Oreg., Oregon.
Pa., Pennsylvania.
R. I., Rhode Island.
S. C., South Carolina.
S. Dak., South Dakota.
Tenn., Tennessee.
Tex., Texas.
Vt., Vermont.
Va., Virginia.
Wash., Washington.
W. Va., West Virginia.
Wis., Wisconsin.
Wyo., Wyoming.

---

[1] See also Clarke, F. W., Some geochemical statistics: Am. Philos. Soc. Proc., vol. 51, p. 214, 1912.

ANALYSES OF IGNEOUS AND CRYSTALLINE ROCKS.

MAINE.

1. ROCKS FROM AROOSTOOK COUNTY.

Described by H. E. Gregory in Bull. 165. Analyses by W. F. Hillebrand, record No. 1795.

A. Quartz trachyte (bostonite), Quoggy Joe Mountain, Presque Isle Township. *Liparose.* Contains quartz, orthoclase, albite, and magnetite, with siderite, kaolin, and chlorite.

B. Teschenite, Mapleton Township. *Akerose.* In dikes cutting shales. Contains andesine, augite, biotite, apatite, analcite, and magnetite.

C. Andesite, Edmunds Hill, Chapman Township. *Tonalose.* Contains labradorite, orthoclase, pyroxene, apatite, and magnetite.

D. Calciferous sandstone, New Sweden Township. Contains calcite, alkali feldspar, quartz, magnetite, muscovite, and siderite. Included here because studied as one of the group.

E. Diabase (basaltic glass), Mars Hill. *Ornose.* Not resolvable into minerals.

F. Rhyolite, Haystack Mountain. *Liparose.* Contains quartz, albite, and orthoclase, with sphene and accessory chlorite and kaolin.

G. Volcanic tuff, southeast base of Castle Hill. Contains fragments of trachyte, andesite, devitrified glass, and lapilli.

H. Diabase, Aroostook Falls, near Maine boundary line. *Beerbachose.* Dike. Contains plagioclase, pyroxene, pyrite, apatite, chlorite, and a little calcite.

	A	B	C	D	E	F	G	H
SiO_2	72.77	46.77	61.40	54.23	42.25	75.98	31.42	49.64
Al_2O_3	12.15	14.91	16.59	7.38	16.87	12.34	11.57	15.07
Fe_2O_3	.44	7.80	2.13	.54	5.24	.85	2.37	1.66
FeO	3.06	4.90	3.05	1.37	10.72	.93	7.48	8.82
MgO	.22	2.94	2.73	3.29	6.91	.15	5.32	5.43
CaO	.07	6.30	6.17	14.56	3.33	.13	16.71	7.23
Na_2O	3.38	4.97	3.83	1.65	3.96	4.02	2.26	4.19
K_2O	4.67	2.37	1.34	1.74	.77	4.44	.74	.89
H_2O-	.17	.92	.82	.25	.43	.24	.76	.45
H_2O+	.55	4.28	.88	1.22	5.58	.64	4.17	2.81
TiO_2	.20	2.31	.79	.28	2.93	.17	2.30	2.32
P_2O_5	Trace.	.98	.20	.07	.34	.03	.46	.29
ZrO_2	.04	None.	None.	(?)	None.	.03	None.	None.
Cr_2O_3	None.	None.	Trace.	(?)	.03	(?)	Trace.	Trace.
V_2O_3	(?)	.02	.02	(?)	.07	(?)	.06	.04
FeS_2	.12	.07	None.	(?)	Trace.	None.	.16	.79
NiO	None.	Trace.	Trace.	None.	.01	None.	Trace.	Trace.
MnO	.16	.29	.13	Undet.	.40	Trace?	.38	.25
SrO	None.	.03	Trace?	None.	None.	Trace?	None.	.05
BaO	.03	.04	.02	None.	Trace?	.07	.64	.02
CO_2	2.06	Trace?	None.	13.48	None.	None.	13.13	.32
	100.09	99.90	100.10	100.06	99.84	100.02	99.93	100.27

Traces of lithia present in all. F and Cl not looked for.

2. MISCELLANEOUS ROCKS.

A. Elæolite syenite, var. litchfieldite, from Litchfield. *Nordmarkose.* Described by Bayley in Bull. 150, p. 201; and in Bull. Geol. Soc. America, vol. 3, p. 231. Contains elæolite, two feldspars, and lepidomelane, with sodalite, cancrinite, and zircon as accessories. Analysis by L. G. Eakins, record No. 1298. P. R. C. 77 and 949.

For analyses of feldspar, elæolite, hydronephelite, lepidomelane, sodalite, and cancrinite from this rock, see pages 300, 309, 310, 329, and 334.

B. Syenite porphyry, Appleton, Knox County. *Prowersose.* Described by E. S. Bastin in Jour. Geology, vol. 14, p. 173. Contains potash feldspar, albite, biotite, hornblende, zircon, titanite, apatite, iron ores, and a little quartz. Analysis by G. Steiger, record No. 2232.

C. Pyrrhotitic peridotite, East Union. *Lermondose.* Described by Bastin in Jour. Geology, vol. 16, p. 124. Contains pyrrhotite, with some pyrite and chalcopyrite, olivine, plagioclase, hornblende, and magnetite. Also small amounts of biotite and spinel, with secondary serpentine, amphibole, chlorite, and calcite. Analysis by W. F. Hillebrand, record No. 2301. P. R. C. 1659.

D, E. Two pegmatites (graphic-granite), Fisher's quarry, Topsham. *Omeose.* Collected by Bastin. Essentially quartz and orthoclase. Analyses by Steiger, records Nos. 2345, 2357. P. R. C. 1886. Described by Bastin in Bull. 445.

F. Pegmatite, Auburn. *Omeose.* Collected by Bastin. Analysis by Steiger, record No. 2393.

	A	B	C	D	E	F
SiO_2	60.39	52.26	28.04	73.89	73.92	72.76
Al_2O_3	22.57	10.63	3.51	13.75	14.26	15.47
Fe_2O_3	.42	2.47	(?)	.26	.30	
FeO	2.26	5.45	14.95			
MgO	.13	9.32	21.97	None.	None.	None.
CaO	.32	5.62	1.78	None.	None.	.19
Na_2O	8.44	1.60	.28	2.10	2.06	2.35
K_2O	4.77	5.99	.08	9.00	8.99	9.28
H_2O-	.57	.98	1.48	1.21	.11	.15
H_2O+		1.97	2.54			
TiO_2		1.92	.20	None.	None.	
ZrO_2		.08	(?)			
CO_2		.75	1.01			
P_2O_5		.98	.04	Trace.	Trace.	
MnO	.08	.12	.24			
SrO			Trace?			
BaO			(?)			
Li_2O			None.			
Cr_2O_3			Trace.			
Fe_7S_8			21.53			
NiS			.94			
CoS			.03			
$CuFeS_2$			1.03			
	99.95	100.14	99.65	100.21	99.64	100.20

NEW HAMPSHIRE.

A. Elæolite syenite, Red Hill, Moultonboro. *Umptekose.* Described by Bayley in Bull. Geol. Soc. America, vol. 3, p. 231. Contains elæolite, augite, hornblende, biotite, sodalite, albite, and orthoclase, with accessory apatite, sphene, magnetite, and an occasional zircon. Fibrous decomposition products are also present. P. R. C. 203.

B. Mixed albite and orthoclase from A.

C. Nepheline (elæolite) from A. Analysis by W. F. Hillebrand, record No. 1321. The mixed nepheline and feldspar were treated with dilute hydrochloric acid, and the residue was extracted with sodium carbonate solution. C represents the soluble part and B the insoluble.

D. Camptonite, Campton Falls. Analysis by L. G. Eakins, record No. 1298. Described by J. P. Iddings in Bull. 150, p. 239. Contains hornblende, plagioclase, orthoclase, augite, iron ore, biotite, apatite, pyrite, and a mineral which appears to be analcite. Also variable calcite, serpentine, and chlorite. P. R. C. 92.

E. Quartz porphyry, Pemigewasset. *Toscanose.* Analysis by Eakins, No. 1298.

	A	B	C	D	E
SiO_2	59.01	66.85	45.31	38.45	65.02
Al_2O_3	18.18	19.50	32.67	19.68	17.93
Fe_2O_3	1.63	.13	....	4.01	4.69
FeO	3.65		....	11.15	.17
MgO	1.05	Trace.	.16	6.65	1.24
CaO	2.40	.11	2.00	9.37	1.34
Na_2O	7.03	7.44	12.60	2.77	3.04
K_2O	5.34	5.80	5.70	1.72	5.98
H_2O-	.15	....	....	1.49	.86
H_2O+	.50	.31	1.56		
TiO_2	.81	....	....	....	....
P_2O_5	Trace.	....	....	....	....
MnO	.03	....	....	Trace.	.11
SrO	Trace.	....	....	....	....
BaO	.08	.07	....	....	....
Li_2O	Trace.	None.	....	....	....
CO_2	.12	....	....	4.82	....
	99.98	100.21	100.00	100.11	100.38

VERMONT.

1. ROCKS OF MOUNT ASCUTNEY.

Described by R. A. Daly in Bull. 209. Analyses by W. F. Hillebrand, record Nos. 1621, 1657.

A. Biotite granite. *Liparose.* Contains quartz, orthoclase, plagioclase (microperthite), biotite, magnetite, sphene, apatite, and zircon. P. R. C. 1340.

B. Basic segregation in biotite granite. *Akerose.* Contains biotite, hornblende, quartz, plagioclase, microperthite, much sphene and apatite, some magnetite and zircon. P. R. C. 1338.

C. Another sample of B, but containing more hornblende. *Akerose.* P. R. C. 1339.

D. Nordmarkite. *Phlegrose.* Contains orthoclase, plagioclase, quartz, hornblende, magnetite, apatite, and zircon, with very little biotite, titanite, diopside, and allanite. P. R. C. 1341.

E. Basic segregation in nordmarkite. *Akerose.* Contains hornblende, augite, microperthite, orthoclase, plagioclase, quartz, magnetite, zircon, and apatite. P. R. C. 1342.

F. Hornblende paisanite. *Liparose.* Dike. Contains orthoclase, quartz, hornblende, magnetite, apatite, and zircon. P. R. C. 1347.

	A	B	C	D	E	F
SiO_2	71.90	56.01	59.27	65.43	56.51	73.03
Al_2O_3	14.12	[a] 15.19	15.76	16.11	16.59	13.43
Fe_2O_3	1.20	2.34	2.07	1.15	1.35	.40
FeO	.86	4.89	3.57	2.85	6.59	1.49
MgO	.33	4.67	3.04	.40	2.52	.14
CaO	1.13	4.85	3.69	1.49	4.96	.79
Na_2O	4.52	5.66	5.63	5.00	5.15	4.91
K_2O	4.81	2.16	3.33	5.97	3.05	4.54
H_2O-	.18	.36	.23	.19	.21	.18
H_2O+	.42	.90	.74	.39	.71	.35
TiO_2	.35	1.13	1.12	.50	1.20	.30
P_2O_5	.11	.53	.42	.13	.41	.06
ZrO_2	.04	....	.04	.11	.04	.06
MnO	.05	.40	.37	.23	.24	.15
(NiCo)O	None.	.03	Trace?	(?)	Trace?	(?)
BaO	.04	Trace?	Trace?	.03	.03	Trace?
CO_2	.21	Undet.	.30	Trace?	.33	Trace?
F	.06	Undet.	.42	.08	.24	.08
Cl	.02	Undet.	.03	.05	.07	.03
FeS_2	Trace?	.09	.07	.07	.06	.09
	100.35	99.21	100.10	100.18	100.26	100.03
Less O	.03	....	.19	.04	.11	.04
	100.32	....	99.91	100.14	100.15	99.99

[a] Including ZrO_2.

G. Nordmarkite. *Phlegrose*. Contains orthoclase, plagioclase, microperthite, hornblende, quartz, augite, magnetite, biotite, apatite, and zircon. P. R. C. 1343.

H. Hornblende paisanite. *Liparose*. Composition like D, but with more quartz. P. R. C. 1348.

I. Basic segregation in H. *Akerose*. Contains hornblende, green and brown augite, biotite, quartz, microperthite, magnetite, little apatite, and zircon. P. R. C. 1349.

J. Diorite. *Andose*. Contains hornblende, augite, biotite, plagioclase, titaniferous magnetite, sphene, zircon, and quartz. P. R. C. 1344.

K. Windsorite. *Toscanose*. Contains plagioclase, orthoclase, quartz, biotite, magnetite, ilmenite, and very small amounts of diopside, apatite, and zircon. P. R. C. 1345.

	G	H	I	J	K
SiO_2	64.88	73.69	56.53	52.12	64.62
Al_2O_3	16.24	12.46	16.47	16.35	16.46
Fe_2O_3	1.37	1.21	1.58	3.68	1.82
FeO	2.70	1.75	5.40	6.02	2.14
MgO	.89	.17	2.67	4.14	1.10
CaO	1.92	.36	4.90	7.25	2.39
Na_2O	5.00	4.47	5.59	3.65	4.57
K_2O	5.61	4.92	3.80	2.34	5.21
H_2O-	.19	.14	.23	.25	.13
H_2O+	.46	.24	.60	.88	.39
TiO_2	.69	.28	1.40	2.10	.81
P_2O_5	.13	.04	.27	.89	.21
ZrO_2	.13	.14	.03	.02	.03
MnO	.14	.15	.20	.17	.12
(NiCo)O	None.	None.	Trace.	Trace.	None.
BaO	.06	None.	Trace.	.04	.03
CO_2	None.	Trace.	.05	.07	.11
F	.08	.05	.19	.03	Undet.
Cl	.04	.02	.07	.09	.05
FeS_2	None.	None.	Trace.	.24	.19
	100.53	100.09	99.98	100.33	100.38
Less O	.04	.02	.09	.03	.01
	100.49	100.07	99.89	100.30	100.37

L. Basic segregation in diorite. *Akerose.* Contains hornblende, augite, biotite, plagioclase, magnetite, apatite, zircon, and a little quartz. P. R. C. 1346.

M. Diabase. *Auvergnose.* Contains plagioclase, augite, and magnetite P. R. C. 1351.

N. Camptonite. *Camptonose.* Contains brown hornblende, plagioclase, a little augite, olivine, magnetite, and apatite. P. R. C. 1350.

O. Phyllite. Contains quartz, sericite, graphite?, magnetite, pyrite, rare orthoclase, plagioclase, sphene, and rutile. A quartz-sericite schist. P. R. C. 1352.

P. Cordierite-microperthite hornfels. *Akerose.* Contains biotite, quartz, red garnet, corundum, magnetite, iolite, microperthite, and rarely pleonaste.

Q. Cordierite hornfels. Contains quartz, biotite, pleonaste, corundum, iolite, magnetite, plagioclase, red garnet, and epidote?.

	L	M	N	O	P	Q
SiO_2	55.28	49.63	48.22	90.91	58.35	45.30
Al_2O_3	17.23	14.40	14.27	4.18	21.30	30.51
Fe_2O_3	1.54	2.85	2.46	.22	.03	.24
FeO	6.23	8.06	9.00	1.27	6.41	8.80
MgO	2.69	7.25	6.24	.37	2.10	3.11
CaO	5.60	9.28	8.45	.22	.85	.90
Na_2O	5.42	2.47	2.90	.77	1.60	1.65
K_2O	2.12	.70	1.93	.56	5.63	4.84
H_2O-	.20	.27	.28	.06	.31	.26
H_2O+	.71	1.47	1.66	.74	.86	1.05
TiO_2	1.64	1.68	2.79	.28	.87	1.48
P_2O_5	.73	.25	.64	.05	.18	.12
ZrO_2	Trace.	Trace?	.03	.02	None.	None.
MnO	.24	.17	.20	Trace.	.13	.20
(NiCo)O	(?)	.04	.03	None.	.03	.02
BaO	.06	Trace?	.04	Trace.	.05	.03
CO_2	.04	1.36	.15	.18	....	....
C	....	....	....	.10	.40	.17
SO_3	None.	None.	None.	None.	None.	.04
Cl	.07	.07	.10	....	.03	.04
F	.28	Trace.	.05	Trace.	(?)	.04
FeS_2	.07	.22	.36	.11	.58	1.07
	100.15	100.17	99.80	100.06	99.71	99.87
Less O	.13	.02	.04	....	....	....
	100.02	100.15	99.76	....	....	....

In these rocks the sulphur is all reckoned as pyrite, although pyrrhotite also is probably present. The carbonic acid represents either dolomite or siderite; not calcite. Traces of lithia and strontia occur in nearly all. Samples H, L, O, and Q contain traces of copper. In N there is 0.03 V_2O_3, a supplementary determination by Hillebrand.

2. MISCELLANEOUS ROCKS.

A. Amphibolite, Guilford. Described by Emerson in Mon. XXIX. Contains hornblende needles, with albite and rutile. Analysis by L. G. Eakins, record No. 1326. P. R. C. 1615.

B. Granitoid gneiss, north of Lincoln's.

C. The same, west slope of Little Peco.

D. Chloritic granite. *Susquehannose.* East Clarendon section.

E. Hornblende granite. *Hessose.* East Clarendon.

Rocks B, C, D, and E collected by C. L. Whittle, but not described. Analyses by H. N. Stokes, record No. 1396.

	A	B	C	D	E
SiO_2	49.16	71.02	69.97	67.33	52.60
Al_2O_3	16.43	15.00	14.90	16.20	18.45
Fe_2O_3	3.92	1.12	2.16	1.40	2.47
FeO	7.19	1.81	.96	2.73	6.11
MgO	8.19	.69	.37	1.31	4.22
CaO	9.21	.31	.45	2.81	7.55
Na_2O	3.70	2.48	2.85	3.15	3.24
K_2O	.41	5.79	6.54	2.14	1.12
H_2O	.45	1.14	.66	1.84	2.53
TiO_2	1.03	.35	.44	.80	1.11
P_2O_5	.16	.13	.12	.16	.20
Cr_2O_3	Trace.	....	....	....	....
MnO	.23	Trace.	Trace.	Trace.	.23
BaO	.02	Trace.	.09	.05	....
	100.10	99.84	99.51	99.92	99.83

MASSACHUSETTS.

1. MAGNESIAN ROCKS.

A. Cortlandtite, Belchertown. *Belcherose*. Described by B. K. Emerson in Mon. XXIX. Contains hornblende, pyroxene, biotite, olivine, and magnetite. Analysis by L. G. Eakins, record No. 1326. P. R. C. 1616.

B. Wehrlite, New Braintree. *Cookose*. Description furnished by Emerson. Contains diallage, enstatite, augite, anorthite, biotite, apatite, chromite, magnetite, and pyrrhotite. Analysis by L. G. Eakins, record No. 1327. P. R. C. 1617.

C. Black, serpentinized boltonite, Stow. Collected by Emerson. Analysis by W. F. Hillebrand, record No. 1555. P. R. C. 1618.

	A	B	C
SiO_2	48.63	50.64	36.92
Al_2O_3	5.32	7.93	.10
Fe_2O_3	2.91	1.41	1.19
FeO	3.90	14.82	.87
MgO	21.79	18.58	43.99
CaO	13.04	3.41	.59
Na_2O	.34	.96	....
K_2O	.23	.21	.05
H_2O-	2.81	.87	.72
H_2O+			14.70
TiO_2	.47	.82	None.
CO_2	Trace.	....	.90
P_2O_5	.21	.27	Trace.
Cr_2O_3	.36	.05	None.
MnO	.12	.16	Trace.
BaO	Trace.	....	None.
	100.13	100.13	100.03

The following serpentinous rocks are described by Emerson in Mon. XXIX:

D. Serpentine, derived from salite, Osburn's soapstone quarry, Blandford. P. R. C. 1619.

E. Dark-green, oily serpentine, center of large Middlefield bed. P. R. C. 1620.

F. Enstatite, slightly altered, from Granville. For comparison with G. P. R. C. 1621.

G. Serpentine, derived from enstatite, Granville. P. R. C. 1622.

Analyses D, E, and F by W. F. Hillebrand, record No. 1555. Analysis G by George Steiger, No. 1536.

	D	E	F	G
SiO_2	40.77	38.62	54.04	37.82
Al_2O_3	1.16	.35	.52	.61
Fe_2O_3	3.56	3.44	1.51	7.92
FeO	1.47	3.99	3.90	1.15
MgO	39.37	40.61	34.40	37.94
CaO	None.	.40	None.	None.
Na_2O	.14	.10	.08	Trace.
K_2O	.10	.08		
H_2O-	.49	.36	.70	.75
H_2O+	12.48	10.91	3.07	12.50
TiO_2	None.	None.	None.	Trace.
P_2O_5	Trace.	Trace.	None.	Trace.
Cr_2O_3	.28	.39	.14	.19
MnO	.09	.10	.11	....
NiO	.17	.21	.23	.45
CoO	....	....	....	.05
Li_2O	Trace.	Trace.	....	....
CO_2	None.	.52	1.32	....
	100.08	100.08	100.02	99.38

H. Rich, dark-green serpentine, Rowe. P. R. C. 1623.

I. Black serpentine, containing marmolite, Atwater's quarry, Russell. P. R. C. 1624.

J. Blackish-green serpentine, containing much chromite. From "The Crater," North Blandford. P. R. C. 1625.

K. Gray, splintery serpentine, Chester. P. R. C. 1626.

Analyses by Steiger, record No. 1536.

	H	I	J	K
SiO_2	40.42	36.94	39.14	33.87
Al_2O_3	1.86	.50	1.18	.77
Fe_2O_3	2.75	6.04	4.46	2.81
FeO	4.27	1.94	3.14	4.25
MgO	35.95	38.35	41.45	38.57
CaO	.66	None.	None.	None.
Na_2O	.16	None.	None.	None.
K_2O				
H_2O-	.21	.71	.34	.38
H_2O+	10.51	12.07	9.48	7.00
TiO_2	None.	Trace.	None.	None.
P_2O_5	Trace.	Trace.	.02	Trace.
Cr_2O_3	.28	.33	.33	.38
MnO	Trace.	Trace.	None.	.04
NiO	.53	.40	.47	.33
CoO	Trace.	None.	Trace.	
CO_2	1.44	1.85	None.	10.82
SO_3	Trace.	.20	None.	.20
FeS_2	.43	....	....	....
	99.47	99.33	100.01	99.42

2. AMPHIBOLITE.

Rocks A to G are described by Emerson in Mon. XXIX.

A. Amphibolite, Bernardston. A black, heavy, massive hornblende rock. Analysis by L. G. Eakins, record No. 1327. P. R. C. 1627.

B. Porphyritic amphibolite, Heath. Analysis by Eakins, record No. 1325. P. R. C. 1628.

C. Amphibolite, New Salem. Analysis by Eakins, record No. 1325. P. R. C. 1629.

D. Amphibolite, Whitmans Ferry, Sunderland. Thin, shaly, aphanitic. Analysis by Eakins, record No. 1325. P. R. C. 1630.

	A	B	C	D
SiO_2	51.72	51.38	45.48	49.86
Al_2O_3	16.51	18.01	19.43	15.50
Fe_2O_3	1.72	3.30	.13	2.99
FeO	9.56	8.53	6.58	8.01
MgO	6.58	5.08	11.08	7.79
CaO	8.89	6.27	10.66	8.89
Na_2O	2.74	5.34	2.28	3.26
K_2O	.34	.18	.11	.72
H_2O	.51	.56	3.17	1.51
TiO_2	1.39	1.07	.77	1.58
P_2O_5	.23	.18	.14	.11
Cr_2O_3	....	....	Trace.	....
MnO	Trace.	.19	Trace.	.07
BaO	Trace.	Trace.	.01	Trace.
CO_2	....	....	.20	....
	100.19	100.09	100.04	100.29

E. Amphibolite, South Leverett. Deep green, ligniform. Analysis by L. G. Eakins, record No. 1327. P. R. C. 1631.

F. Amphibolite, Goshen. Derived from Conway limestone. Analysis by Eakins, record No. 1414. P. R. C. 1632.

G. Black, fissile amphibolite, Worthington. Nearly pure, matted hornblende Titanite and sometimes zircon present. Analysis by Eakins, record No. 1326. P. R. C. 1633.

H. Black, fissile, porphyritic amphibolite, Warwick. Analysis by Eakins, record No. 1414. Collected by Emerson, but not described in Mon. XXIX. P. R. C. 1634.

	E	F	G	H
SiO_2	47.56	55.64	48.53	50.65
Al_2O_3	16.13	16.27	16.35	13.08
Fe_2O_3	1.80	1.22	2.03	.27
FeO	9.39	7.20	10.52	12.67
MgO	9.21	5.58	9.71	16.96
CaO	6.67	9.23	9.83	1.73
Na_2O	2.52	.91	1.36	1.37
K_2O	1.58	.19	.32	.04
H_2O	3.51	3.11	.79	2.96
TiO_2	1.24	.50	.51	.50
P_2O_5	.21	.23	.07	Trace.
Cr_2O_3	Trace.	....	....	Trace.
MnO	.08	.28	.17	.15
BaO	Trace.	....	Trace.	....
	99.90	100.36	100.19	100.38

The following amphibolites, from Palmer Center, were also collected by Emerson:

I. Amphibolite dike. P. R. C. 1635.

J. Hornblende, separated from I.

K. Feldspar, separated from I.

L. Amphibolite bed. P. R. C. 1636.

M. Hornblende, separated from L.

N. Feldspar, separated from L.

Analyses I to N by W. F. Hillebrand, record No. 1895.

	I	J	K	L	M	N
SiO_2	49.57	43.11	62.91	51.25	44.09	60.90
Al_2O_3	14.23	11.10	23.37	16.53	10.68	24.97
Fe_2O_3	3.95	4.97		1.81	2.72	
FeO	8.01	13.04		7.67	12.96	
MgO	6.14	9.35		5.87	10.75	
CaO	10.19	11.76	5.83	9.32	11.58	7.85
Na_2O	3.06	1.18	7.78	3.35	1.19	6.26
K_2O	.95	1.27	.20	.78	.88	.16
H_2O-	.14	.16	.42	.19	.21	.48
H_2O+	1.33	1.92		1.26	1.91	
TiO_2	2.03	1.32		1.84	1.73	
CO_2	Trace.					
P_2O_5	.21	.10		.31	.10	
S	.02			(?)		
V_2O_3	.04	.07		Undet.	Undet.	
Cr_2O_3	Trace.	Trace.		Trace.	Trace.	
NiO	Trace.	Trace.		Trace.	Trace.	
MnO	.27	.43		.28	.32	
SrO	Trace?	None.	(?)	(?)	None.	(?)
BaO	Trace.	None.	(?)	(?)	None.	(?)
Li_2O	Trace.	(?)	(?)	Trace.	(?)	(?)
	100.14	99.78	100.51	100.46	99.12	100.62
Specific gravity		3.220,21.5°	2.667,24°		3.217,29°	2.677,22°

3. GRANITE AND GNEISS.

Analyses A to F are of rocks collected by B. K. Emerson, and as yet undescribed.

A. Gneissoid granite, north wall of Flint's quarry, Monson. *Amadorose.* Analysis by W. F. Hillebrand, record No. 1924. P. R. C. 1645.

B. Gneissoid granite, Frawley's quarry, Erving. *Tehamose-toscanose.* Analysis by George Steiger, record No. 1941. P. R. C. 1648.

C. Gneissoid granite, Alderman's quarry, Becket. *Toscanose-lassenose.* Analysis by Steiger, No. 1944. P. R. C. 1649.

D. Gneissoid biotite granite, Wood's quarry, Pelham. *Toscanose.* Analysis by Steiger, No. 1960. P. R. C. 1650.

E. Aplite (alsbachite), Fallon Hill, Enfield. *Kallerudose.* Garnetiferous biotite granite dike. P. R. C. 1651.

F. Another sample, same locality as M. *Lassenose-alsbachose.* P. R. C. 1652.

Analyses E, F, by Steiger, record No. 1975.

	A	B	C	D	E	F
SiO_2	65.02	74.15	70.62	72.45	77.00	73.09
Al_2O_3	18.37	13.35	15.31	13.32	13.60	13.42
Fe_2O_3	1.21	1.26	1.06	1.93	.41	1.44
FeO	2.06	.53	.43	.63		1.13
MgO	1.49	.23	.29	.44	None.	.35
CaO	6.20	1.92	1.30	1.81	.70	1.89
Na_2O	3.96	2.84	4.55	3.55	5.78	4.52
K_2O	.64	4.58	4.01	3.86	1.50	1.59
H_2O-	.09	.13	.16	.59	.23	.47
H_2O+	.42	.50	.72	1.51	.48	1.41
TiO_2	.33	.12	.29	.27	.07	.26
CO_2	None.	None.	.88	None.		
P_2O_5	.14	.06	.07	.06	Trace.	.05
MnO	.09				None.	.10
BaO	Trace.					
	100.02	99.67	99.69	100.42	99.77	99.72

G. Biotite granite, Moore's quarry, Florence. *Lassenose.* Very feldspathic. Quartz rare, with fluid inclusions. Feldspar mostly triclinic, orthoclase and microcline present in small quantities. Little muscovite, some rutile. Analysis by Eakins, record No. 1414. P. R. C. 1642. Described by Emerson in Mon. XXIX.

H. Granite gneiss, Hoosac Mountain. *Toscanose.* Contains quartz, microcline, albite, muscovite, biotite, magnetite, titanite, epidote, apatite, and zircon. Analysis by E. T. Allen, record No. 2064. P. R. C. 1718. Collected by J. E. Wolff, but not yet described.

I. Composite sample of Becket (igneous) gneiss from 33 localities in the Sheffield quadrangle. *Toscanose.* Contains quartz, orthoclase (microcline), oligoclase, biotite, hornblende, and minor accessories. Collected by Joseph Barrell and analysed by R. C. Wells, record No. 2528.

J. Composite sample of Dalton (sedimentary) gneiss, from 36 localities in the Sheffield quadrangle. *Magdeburgose.* Contains quartz, orthoclase (microcline), albite, anorthite, magnetite, ilmenite, biotite and muscovite. Collected by Barrell and analysed by Wells, No. 2528.

K. Pyroxene-titanite aplite, South Peru. *II. 5.2.5.* Analysis by W. T. Schaller, record No. 2143. P. R. C. 1715.

L. Pre-Cambrian quartzite gneiss, Northbridge. Analysis by E. C. Sullivan, record No. 2321.

Rocks K, L, collected by Emerson, but not described.

	G	H	I	J	K	L
SiO_2	73.27	67.12	68.56	71.82	60.44	75.05
Al_2O_3	15.51	14.97	14.53	13.12	16.26	12.83
Fe_2O_3	.33	2.61	1.41	.41	.07	1.11
FeO	1.14	2.19	2.91	2.69	3.52	.53
MgO	.15	.54	.60	None.	1.75	.31
CaO	2.74	1.69	2.69	.54	7.86	.85
Na_2O	4.79	3.92	3.58	.87	7.13	3.02
K_2O	1.66	5.15	3.62	7.17	.44	5.14
H_2O-	.68	.19	.06	.21	.29	.72
H_2O+		1.13	.97	2.35	.38	.62
TiO_2	.10	.37	.55	.86	1.33	.20
CO_2	....	....	Trace.	None.	None.	.07
ZrO_2	....	.03	.02	.07	.06	.02
P_2O_5	Trace.	.14	.17	.14	.58	.04
Cl	....	....	....	....	....	Trace.
F	....	....	.02	....	....	Trace?
S	....	None.	.03	Trace.	None.	.01
MnO	Trace.	.02	.03	.02	.06	.08
NiO	....	....	....	....	Trace.	....
BaO	....	.19	.07	.02	Trace?	.08
SrO	....	....	....	....	Trace?	Trace.
Cr_2O_3	....	Trace.	....	....	....	....
Li_2O	....	....	....	....	None.	Trace.
FeS_2	....	....	....	....	.10	....
	100.37	100.26	99.82	100.29	100.27	100.58

4. MISCELLANEOUS ROCKS.

A. Keratophyre, Marblehead Neck. *Liparose.* Described by Sears, in Bull. Mus. Comp. Zool., vol. 16, No. 9, p. 170. Contains crystals of feldspar, with a decomposed base, irregular patches of quartz, some scales of biotite and grains of magnetite, and also some limonite and earthy matter. The feldspar is anorthoclase. P. R. C. 1491.

B. Feldspar, separated from A. Analyses A and B by T. M. Chatard, record No. 1176.

C. Highly metamorphosed feldspathic conglomerate, graduating into arkose gneiss, electric railroad cut, Marlboro. Analysis by George Steiger, record No. 1536. P. R. C. 1637.

D. Ægirite tinguaite, Southboro. *Miaskose*. Analysis by H. N. Stokes, record No. 1653. Contains traces of chlorine and fluorine; 63.2 per cent of the rock is decomposable by hydrochloric acid. P. R. C. 1639.

Rocks C and D were collected by B. K. Emerson, but have not been fully described.

	A	B	C	D
SiO_2	70.23	65.66	75.35	54.22
Al_2O_3	15.00	20.05	13.03	20.20
Fe_2O_3	1.99	Trace.	.62	2.35
FeO	Undet.	Trace.	.94	1.02
MgO	.38	.18	.21	.29
CaO	.33	.67	1.33	.70
Na_2O	4.98	6.56	2.44	9.44
K_2O	4.99	6.98	5.14	4.85
H_2O-	.91	.04	.15	.42
H_2O+	1.28	.37	.73	5.57
TiO_2	(?) .03	Undet.	.21	.38
CO_2	....	....	.03	Trace.
P_2O_5	.06	Undet.	.08	.11
SO_3	....	....	.03	None.
MnO	.24	.13	None.	.19
BaO	....	....	.07	Trace.
	100.42	100.64	100.36	99.74

E. Massive, coarse, altered diabase, Leverett. *Ornose*. Contains saussuritic feldspar with black hornblende. Analysis by Eakins, record No. 1325. P. R. C. 1640.

F. Tonalite, South Leverett. *Andose*. Dark green, chloritic. Contains reddish feldspar, dark hornblende, and a network of dark-green epidotic quartz veins. Analysis by Eakins, record No. 1326. P. R. C. 1641. Rocks E, F, described by Emerson in Mon. XXIX.

G. Holyokeite, east foot of Mount Tom, Northampton. Probably *tuolumnose*. Described by Emerson in Jour. Geology, vol. 10. p. 508. Contains albite, 70 per cent; orthoclase, 9.4 per cent; calcite, 16.4 per cent, with minor amounts of ilmenite, dolomite, chalcopyrite, pyrite, and apatite. Analysis by W. F. Hillebrand, record No. 1924. P. R. C. 1643.

H. Quartz diabase, west of Ashley Reservoir, Holyoke. *Vaalose*. Contains calcite and radiated quartz. P. R. C. 1653.

I. Palagonite, from blebs in H.

Analyses H, I, by Steiger, No. 2039; rocks described by Emerson in Bull. Geol. Soc. America, vol. 16, p. 91.

	E	F	G	H	I
SiO_2	51.56	55.51	53.83	53.52	40.35
Al_2O_3	14.82	16.51	16.36	9.70	5.11
Fe_2O_3	4.30	1.68	.89	8.06	24.99
FeO	7.21	4.57		9.45	3.55
MgO	7.36	6.73	.13	2.52	5.48
CaO	7.09	6.73	9.81	5.64	1.32
Na_2O	4.21	3.19	7.89	2.24	.18
K_2O	.17	2.46	1.58	1.50	1.44
H_2O-	1.47	1.53	.15	1.67	8.51
H_2O+			.36	2.16	8.51
TiO_2	1.97	.91	.86	1.98	.20
CO_2	....	....	7.47	1.02	....
ZrO_2	....	....	.02	.03	None.
P_2O_5	.09	.17	.11	.36	....
S	....	....	.17	.10	None.
Cu	....	....	.14	....	....
MnO	Trace.	.11	Undet.	.26	.22
BaO	Trace.	.02	(?)	....	....
	100.25	100.12	99.77	100.21	99.86

J. Diorite, railroad cut west of Ironstone. *Hessose*. Collected by Emerson, but no description furnished. Analysis by E. C. Sullivan, record No. 2321.

K. Albite schist, Hoosac Mountain. *Varingose*. Contains quartz, microcline, albite, muscovite, biotite, magnetite, titanite, epidote, apatite, and zircon. Analysis by E. T. Allen, record No. 2064. Collected by J. E. Wolff, but not yet described. P. R. C. 1719.

The following feldspars, all albite, separated from schists of the same region as K, are described by Wolff in Mon. XXIII, pp. 60, 187. Analyses by R. B. Riggs, record No. 507, 567.

L. From feldspathic schist, central shaft of the Hoosac Tunnel. P. R. C. 129.

M, N. From the porphyritic mica schist of Greylock Mountain.

O. Composite sample of Berkshire schist, section across Mount Washington, Sheffield quadrangle. Contains quartz, muscovite, biotite, plagioclase feldspar, garnet, staurolite, calcite, magnetite and graphite. Collected by Joseph Barrell and analyzed by R. C. Wells, record No. 2431.

	J	K	L	M	N	O
SiO_2	47.18	70.95	69.69	68.08	67.83	59.29
Al_2O_3	16.90	9.99	[a]18.60	[a]20.11	[a]19.92	19.54
Fe_2O_3	5.21	3.08				1.82
FeO	7.22	6.10				5.65
MgO	3.71	1.08	.20	(?)	(?)	1.75
CaO	9.69	.38	Trace.	Trace.	Trace.	1.16
Na_2O	2.76	1.69	10.28	11.00	11.65	1.25
K_2O	.68	3.74	.40	.36	.25	3.25
H_2O-	.92	.40	[b].42	[b].31	[b].12	.13
H_2O+	1.66	1.82				4.06
TiO_2	2.94	.63				.99
ZrO_2	Trace.	.04				.01
CO_2	.63					.20
P_2O_5	.38	.23				.17
S	.22	.05				.04
Cl	Trace.					None.
F	Trace?					None.
Cr_2O_3		Trace.				.02
V_2O_3						.03
MnO	.14	Trace.		Trace.	Trace.	.25
NiO	Trace.					
ZnO	.03					
BaO	.01	.04				.05
SrO	Trace.					Trace.
	100.28	100.22	99.59	99.86	99.77	99.66

[a] Fe_2O_3 less than 0.5 per cent.

[b] Loss on ignition.

CONNECTICUT.

A. Olivine basalt, main flow, Pine Hill, South Britain. *Auvergnose*. Contains plagioclase, pink augite, olivine, and magnetite. The rock is quite fresh. P. R. C. 1456.

B. Olivine basalt, anterior flow, South Britain. Contains plagioclase, uralitized augite, olivine, and magnetite. Rock much altered, and containing numerous amygdules of calcite and prehnite stained by iron. P. R. C. 1457.

Rocks A and B are described by W. H. Hobbs in 21st Ann. Rept., pt. 3, p. 60. Analyses by W. F. Hillebrand, record No. 1842.

C. Basic pitchstone (tachylyte), from the so-called "ash bed" northeast of Meriden. *SR. 1-2 of auvergnase*. Described by Emerson in Bull. Geol. Soc. America, vol. 8, p. 77. Analysis by H. N. Stokes, record No. 1641. P. R. C. 1654.

D. Pegmatite, Andrew's quarry, Portland. *Omeose*. Described by Bastin in Bull. 445. Analysis by G. Steiger, record No. 2393.

	A	B	C	D
SiO_2	52.40	47.52	46.86	71.00
Al_2O_3	13.55	13.91	13.96	16.31
Fe_2O_3	2.73	7.06	5.23	....
FeO	9.79	3.76	4.67	....
MgO	5.53	6.84	7.69	None
CaO	10.01	5.71	9.42	.22
Na_2O	2.32	3.06	1.85	3.44
K_2O	.40	.77	2.02	8.66
H_2O-	.62	1.75	1.29	.12
H_2O+	1.05	4.55	3.43	
TiO_2	1.08	1.19	1.13	....
P_2O_5	.12	.15	.15	....
NiO	Trace.	Trace.	....	....
MnO	.26	.18	Trace.	....
SrO	None.	None.	Trace.	....
BaO	Trace?	Trace.	.03	....
Li_2O	None.	Trace.	Trace.	....
CO_2	....	3.68	2.19	....
F	....	....	Trace.	....
FeS_2 or $Fe_7 S_8$ [a]	.13	....	....	....
	99.99	100.13	99.92	99.75

[a] Calculated as pyrite.

The following rocks, E to I, are from Prospect Hill, west of Litchfield. Collected by W. H. Hobbs, who furnishes the petrographic data:

E. Mica-hornblende gabbro. *Bandose.* Contains plagioclase, hypersthene, biotite, subordinate green hornblende, and magnetite. P. R. C. 1677.

F. Hornblende diorite. *Hessose.* Contains plagioclase, green hornblende, subordinate biotite, and magnetite. P. R. C. 1678.

G. Hornblendite. *III. 6. 4. 4. 5.* Almost entirely green hornblende. Contains also magnetite, a little biotite, and very little plagioclase. P. R. C. 1679.

H. Cortlandtite. *IV. 1^2. 1^2. 2.* Mainly hypersthene, with subordinate olivine, green hornblende, and magnetite. P. R. C. 1680.

I. Hornblende norite. *Auvergnose.* Contains greenish hornblende and a little more hypersthene. Rich in plagioclase, with accessory biotite and magnetite. P. R. C. 1681.

Analyses D, G, H, by W. F. Hillebrand, record No. 2074; E and F by George Steiger, record No. 2071.

	E	F	G	H	I
SiO_2	50.46	47.97	38.02	47.87	49.28
Al_2O_3	19.65	17.41	14.64	6.09	15.76
Fe_2O_3	1.66	2.06	5.69	1.40	1.86
FeO	5.15	9.09	10.33	8.14	6.94
MgO	5.31	5.93	10.26	16.33	8.21
CaO	9.66	9.12	9.11	14.49	10.51
Na_2O	3.15	3.08	1.90	.87	2.58
K_2O	1.57	.85	1.66	.55	.76
H_2O-	.74	.30	.74	.26	.47
H_2O+	1.14	1.11	2.35	1.07	1.10
TiO_2	1.18	2.10	4.84	1.20	.87
ZrO_2	Trace?	....	....	Trace?	Trace?
CO_2	None.	.43	None.	.75	.36
P_2O_5	.18	.37	.09	.07	.11
S	Trace.	....	....	....	....
Cr_2O_3	....	....	....	.25	.03
NiO	....	....	....	.04	.09
MnO	.15	.10	.12	.20	.20
BaO	.09	....	....	None.	Trace?
SrO	.03	....	....	None.	None.
Li_2O	Trace?	....	....	None.	None.
FeS_2	....	....	....	.51	.99
$CuFeS_2$	....	....	....	.07	.13
V_2O_3	....	....	....	a little.	(?)
Cu	Trace?	....	....	....	....
	100.12	99.92	99.75	100.16	100.25

The following rocks were collected by G. F. Loughlin and described in Bull. 492. Analyses by G. Steiger, record No. 2231:

J. Norite, near northeast boundary, between Preston and Griswold. *Auvergnose.* Contains plagioclase, pyroxene, hornblende, epidote, zoisite, chlorite, serpentine, pyrite, ilmenite, apatite, and a little calcite.

K. Hornblende gabbro, 1 mile east of Preston City post office. *Auvergnose.* Contains quartz, plagioclase, little orthoclase, hornblende, little biotite, rare muscovite, epidote, zoisite, pyrite, ilmenite, apatite, and zircon.

L. Oligoclase granite dike, southern slope of Barnes Hill, North Stonington. Contains quartz, orthoclase, oligoclase, biotite, muscovite, titanite slightly altered to leucoxene, epidote, chlorite, ilmenite, pyrite (?), zircon, and apatite. Somewhat kaolinized.

M. Amphibolite dike, east base of Prospect Hill, northwest of Preston City post office. *Auvergnose.* Contains plagioclase, hornblende, epidote, ilmenite, pyrite, apatite, and a little kaolin and sericite.

	J	K	L	M
SiO_2	49.98	49.90	73.52	47.63
Al_2O_3	17.65	14.64	12.86	15.49
Fe_2O_3	3.48	4.65	1.48	2.60
FeO	4.85	7.52	1.54	8.70
MgO	7.78	6.06	.57	8.40
CaO	9.42	9.14	2.08	10.04
Na_2O	2.75	2.73	4.36	3.09
K_2O	.17	.46	1.41	.36
H_2O-	1.06	.46	.35	.35
H_2O+	2.23	1.98	1.21	1.78
TiO_2	.87	1.98	.51	1.93
P_2O_5	Trace.	.38	.07	.11
SO_3	....	....	None.	....
S	....	.02	None.	....
MnO	.15	.18	.08	.22
BaO	None.	.02	.02	None.
	100.19	100.12	100.06	100.70

NEW YORK.

1. ROCKS OF THE ADIRONDACK REGION.

Collected by J. F. Kemp, who furnishes the petrographic data. A and G, together with the four iron ores, are described by Kemp in 19th Ann., pt. 3, p. 383. Analyses A and B by George Steiger, record No. 1715; C to K by W. F. Hillebrand, record Nos. 1714 and 1717.

A. Wall rock of iron mine near Lincoln Pond, Elizabethtown. *Camptonose.* Varies from norite to gabbro. Chief minerals, green augite, hypersthene, brown hornblende, plagioclase, and magnetite. Microperthitic feldspar less common. Garnet varies from absence to abundance.

B. Coarse gabbro, top of Whiteface Mountain. *Hessose.* A pyroxenic phase of the anorthosite. Contains much labradorite, abundant light-green augite, brown hornblende, shreds of more or less bleached brown biotite, and magnetite.

	A	B
SiO_2	44.77	53.18
Al_2O_3	12.46	23.26
Fe_2O_3	4.63	1.53
FeO	12.99	1.82
MgO	5.34	2.60
CaO	10.20	11.18
Na_2O	2.47	3.97
K_2O	.95	.86
H_2O-	.12	.15
H_2O+	.48	.98
TiO_2	5.26	.45
P_2O_5	.28	.09
NiO, CoO	Trace?	(?)
MnO	.17	.11
BaO	Trace?	Trace?
CO_2	.37	.34
S	[a] .26	Trace.
	100.75	100.57

[a] Mainly present as pyrrhotite.

C. Pyroxenic anorthosite, Elizabethtown. *Hessose.* Contains largely labradorite, subordinate light-green augite, less brown hornblende, and a little magnetite.

D. Norite, with close affinity to gabbro. *Camptonose.* Intrusion in C. Contains labradorite, hypersthene, garnets, green augite, brown hornblende a little brown biotite, magnetite, and apatite.

E. Diabasic norite or gabbro, Elizabethtown. *Auvergnose.* Contains the same minerals as D.

F. Gneissoid derivative, by pressure, of E. *Camptonose.* The same minerals but with hornblende more abundant.

G. Gabbro, wall rock of Split Rock mine. *Hessose.* Contains augite, hypersthene, brown hornblende, garnet, plagioclase, magnetite, and possibly spinel. P. R. C. 1471.

	C	D	E	F	G
SiO_2	56.94	47.16	44.97	46.74	47.88
Al_2O_3	20.82	14.45	15.38	16.63	18.90
Fe_2O_3	.83	1.61	2.29	2.17	1.39
FeO	3.02	13.81	12.39	10.60	10.45
MgO	2.36	5.24	10.89	6.11	7.10
CaO	9.41	8.13	7.50	8.66	8.36
Na_2O	3.36	3.09	3.02	3.81	2.75
K_2O	1.58	1.20	.56	.96	.81
H_2O-	.21	.12	.10	.12	.18
H_2O+	.59	.48	.65	.73	.43
TiO_2	.44	3.37	1.18	2.54	1.20
P_2O_5	.07	.57	.14	.33	.20
V_2O_3	(?)	(?)	.02	(?)	(?)
NiO, CoO	Trace.	.02	.02	.03	.02
MnO	.11	.24	.22	.26	.16
BaO	.05	Trace.	Trace.	Trace.	Trace.
CO_2	.45	.35	.23	.07	.12
S	Trace.	.14	.06	.11	.07
	100.24	99.98	99.64	99.77	100.02

ZrO_2, Cl, and F not looked for. Cr_2O_3, Li_2O, and SrO present in traces. S is, in part at least, present as pyrrhotite.

The following titaniferous magnetites, from Elizabethtown, are regarded by Kemp as being of magmatic origin, and are therefore included in this tabulation.

H. Near Lincoln Pond.

I. Oak Hill pit.

J. Tunnel Hill.

K. Split Rock mine.

H and I are classed by Washington as *adirondackiase*, J and K as *champlainiase*.

	H	I	J	K
SiO_2	12.42	21.42	13.35	17.90
Al_2O_3	6.46	7.03	8.78	10.23
Fe_2O_3	30.68	30.34	20.35	15.85
FeO	27.92	22.81	28.82	27.94
MgO	3.35	6.92	6.63	6.04
CaO	3.95	3.59	2.15	2.86
Na_2O	.50	.53	Undet.	Undet.
K_2O	.26	.41	Undet.	Undet.
H_2O	.64	.95	1.68	1.33
TiO_2	12.31	5.21	16.45	15.66
CO_2	.32	Trace.	.17	Trace.
C	.05	Trace.	Trace.	None.
P_2O_5	.82	.14	.02	.04
V_2O_3	.04	Undet.	.61	.55
Cl	.12	.42	Little.	None.
F	Trace.	(?)	(?)	(?)
S	.04	.04	.09	.14
MnO	Undet.	Undet.	Undet.	Undet.
Cr_2O_3	None.	None.	.55	.51
	99.88	99.81	99.65	99.15

2. MISCELLANEOUS ROCKS.

A. Augite-scapolite-graphite rock, Ticonderoga. Contains augite, scapolite, calcite, quartz, pyrite, graphite, titanite, and apatite.

B. Graphitic schist, mine of Adirondack Graphite Co., Dresden, 5 miles north of Whitehall. Contains quartz, sericite, biotite, magnetite, pyrite, zoisite, and graphite.

C. Graphitic schist, Hague. Analysis by Chase Palmer, record No. 2569.

D. Hornblende schist, Ticonderoga.

Analyses A, B, D by George Steiger, record No. 2419.

Rocks collected by E. S. Bastin. A and B are described by him in Econ. Geol., vol. 5, p. 134.

	A	B	C	D
SiO_2	47.91	65.10	76.37	48.26
Al_2O_3	6.32	9.15	6.75	13.32
Fe_2O_3	.33	4.68	1.66	1.41
FeO	3.11	3.09		11.55
MgO	11.86	2.21	.91	6.66
CaO	22.88	1.71	1.42	10.55
Na_2O	.40	.24	1.04	3.36
K_2O	.46	2.32	1.32	.80
H_2O-	.10	.50	.38	.06
H_2O+	.96	2.33	1.22	.96
TiO_2	.44	.96	.59	1.99
CO_2	.95	None.	None.	.38
P_2O_5	.25	.74	.74	.20
S	.05	3.26	....	.20
MnO	.08	.03	....	.14
FeS_2	....	....	3.54	....
C	4.00	5.29	4.63	None.
	100.10	101.61	100.57	99.84
Less O	.02	1.63	....	.10
	100.08	99.98	....	99.74

E. Syenite, Fort Ann, Washington County. *Adamellose.* Contains orthoclase, microperthite, hornblende, green augite, and a little quartz.

F. Quartz-biotite-garnet gneiss, Fort Ann. Consists essentially of quartz, garnet, biotite, orthoclase, some plagioclase, and zircons.

E and F were collected by J. F. Kemp, who supplies the petrographic data. Analyses by W. F. Hillebrand, record No. 1930.

G. Pegmatite, Kinkler's quarry, Bedford. *Omeose.* Described by E. S. Bastin in Bull. 445. Analysis by G. Steiger, record No. 2393. P. R. C. 1767.

H. Peridotite, from Dewitt, near Syracuse. A rock described by Darton and Kemp, Am. Jour. Sci., 3d ser., vol. 49, p. 456. Contains olivine, partly serpentinized, biotite, and augite, with magnetite, apatite, and perofskite. Possibly a little chromite also. Classed by Kemp as limburgite. P. R. C. 296. Analysis by H. N. Stokes, record No. 1491. The FeO represents the total iron, because the sulphides present, possibly as pyrrhotite, prevent the separate estimation of the two iron oxides.

I. Cortlandtite, Stony Point. *Auvergnose-casselose.* Analyzed for J. P. Iddings by Steiger, record No. 2616. P. R. C. 1814. Contains hornblende, with less olivine and hypersthene, and still less augite, biotite, plagioclase, magnetite, pyrrhotite, and pleonaste. The petrographic data were determined by G. H. Williams.

	E	F	G	H	I
SiO_2	64.47	65.09	76.37	36.80	43.15
Al_2O_3	10.51	16.37	13.87	4.16	9.53
Fe_2O_3	1.11	.93	Undet.		3.40
FeO	7.37	5.64	Undet.	8.33	11.46
MgO	5.21	2.40	None.	25.98	16.89
CaO	3.10	2.40	.26	8.63	8.58
Na_2O	2.21	3.31	3.74	.17	1.51
K_2O	3.63	1.93	5.24	2.48	.87
H_2O-	.18	.13	.80	.51	.76
H_2O+	.75	.58		6.93	1.28
TiO_2	.65	.93		1.26	2.28
ZrO_2	None.	.01			None.
CO_2	.58	.07		2.95	.34
P_2O_5	.25	.11		.47	.13
S	.12	.03		.95	.14
SO_3				.06	None.
Cr_2O_3	Trace?	Trace.		.20	.04
V_2O_3					.03
MnO	.15	.16		.13	.18
NiO	.04	Trace.		.09	.04
BaO	.04	.03		.12	None.
SrO	Trace.	Trace.		Trace.	None.
Li_2O	None.	Trace.			
	100.37	100.12	99.78	100.22	100.61
Less O	.06			.47	.07
	100.31			99.75	100.54

NEW JERSEY.

Rocks A, B, and C described by J. P. Iddings in Bull. 150, pp. 254, 209, 236. Analyses by Eakins, record No. 1299.

A. Basalt, Watchung Mountain, West Orange. *Auvergnose.* Contains pyroxene, mostly malacolite, plagioclase, magnetite, and glass, with variable amounts of serpentine or chlorite. The feldspar is partly altered into a mineral which is probably prehnite. P. R. C. 102.

B. Elæolite syenite, Beemersville. *Beemerose.* Contains nephelite, orthoclase, ægirite, and biotite, with melanite, sphene, apatite, zircon, and magnetite in smaller amounts. Sodalite is probably present also. P. R. C. 78.

C. Minette, Franklin Furnace. Contains alkali feldspar, biotite, monoclinic pyroxene, magnetite, epidote, calcite, chlorite, apatite, sphene, pyrite, and a little secondary quartz. P. R. C. 91.

D. Nepheline syenite, Brookville. *Viezzenose.* Collected by N. H. Darton and described by F. L. Ransome in Am. Jour. Sci., 4th ser., vol. 8, p. 417. Contains alkali feldspars, nepheline largely altered to secondary minerals, brown amphibole, biotite, cancrinite, plagioclase, muscovite, ægirine-augite, apatite, titanite, fluorite, and a few specks of magnetite. Also secondary analcite, sericite, and natrolite (?). Analysis by Steiger, record No. 1807. P. R. C. 223.

	A	B	C	D
SiO_2	51.36	53.56	40.71	54.68
Al_2O_3	16.25	24.43	19.46	21.63
Fe_2O_3	2.14	2.19	7.46	2.22
FeO	8.24	1.22	6.83	2.00
MgO	7.97	.31	6.21	1.25
CaO	10.27	1.24	11.83	2.86
Na_2O	1.54	6.48	1.90	7.03
K_2O	1.06	9.50	3.26	4.58
H_2O-	1.33	.93	1.53	.27
H_2O+				1.88
TiO_2				.79
P_2O_5				.28
MnO	.09	.10	.18	Trace.
NiO	.03			
BaO				.05
F				.22
SO_3				.07
CO_2			.74	None.
	100.28	99.96	100.01	99.81
Less O=F				.09
				99.72

Rocks E to J collected by W. S. Bayley, who describes E, F, G in folio 157. Analyses by W. T. Schaller, record Nos. 2252, 2255.

E. Pochuck gneiss, Greenwood Lake quadrangle. *Auvergnose.* Contains oligoclase, orthoclase, diopside, hornblende, hypersthene, biotite, magnetite, and quartz.

F. Byram gneiss, 1 mile west of Hibernia. *Tehamose.* Contains potash feldspars (microperthite), but less hornblendic and pyroxenic minerals than the Pochuck gneiss.

G. Losee gneiss, northeast of Berkshire Valley, Lake Hopatcong quadrangle. *Noyangose.* Contains plagioclase, quartz, diopside, hypersthene, biotite, apatite, magnetite, zircon, and titanite.

H. Augitic Losee granite, Lake Hopatcong quadrangle. *Hessose.* P. R. C. 1760.

I. Intermediate gneiss, Oxford Tunnel, Hackettstown quadrangle.

J. Micaceous Oxford gneiss, Oxford Tunnel.

K. Quartz-orthoclase-augite rock, near Marion Station, Jersey City. *Alsbachose.* Collected by J. Volney Lewis. Analysis by Schaller, record No. 2261. P. R. C. 1761.

	E	F	G	H	I	J	K
SiO_2	43.98	77.07	77.53	52.97	61.54	58.75	74.97
Al_2O_3	12.01	12.61	13.60	23.27	17.98	17.16	10.39
Fe_2O_3	6.60	.71	.23	1.31	3.11	5.18	1.56
FeO	12.20	.73	.16	3.31	3.21	3.95	1.47
MgO	5.46	Trace.	Trace.	2.20	.32	.91	1.18
CaO	11.99	.87	.73	10.08	2.29	.62	1.83
Na_2O	2.93	3.43	6.65	4.09	5.85	5.72	3.68
K_2O	1.10	4.06	1.20	.62	4.77	5.40	2.34
H_2O-	.29	.23	.15	.53	.09	.35	.50
H_2O+	1.04	.62	.18	.69	.78	.73	.92
TiO_2	2.25	.12	.16	.38		.65	.70
CO_2	.18	Trace.	Trace.	.26	.42	.13	.11
P_2O_5	.28	Trace?	.03	.22	.18	.20	.14
S							Trace?
MnO	.05	.09	Trace?	.19	.08	.10	.07
SrO							Trace?
BaO							.02
	100.36	99.54	100.62	100.12	100.62	99.84	99.97

PENNSYLVANIA.

Rocks A to D are average samples collected by Florence Bascom within the Philadelphia quadrangle. Analyses by W. F. Hillebrand, record No. 1872. Described by the collector in folio 162.

A. Baltimore gneiss. *Yellowstonose.* Contains quartz, orthoclase, microcline, oligoclase, biotite, hornblende, magnetite, and minor accessories. P. R. C. 1701 to 1705.

B. Mica gneiss. *III. 3. 2. 3.* Consists chiefly of quartz and muscovite, with feldspars and minor accessories. P. R. C. 1707 to 1710.

C. Hornblende gneiss. *Auvergnose.* Contains largely green hornblende and colorless anthophyllite, with plagioclase, magnetite, and scanty secondary quartz. P. R. C. 1710 to 1711.

D. Hypersthene gabbro. *Hessose.* Contains quartz, orthoclase, labradorite, diallage, hypersthene, magnetite, apatite, and minor accessories. P. R. C. 1712 to 1714.

	A	B	C	D
SiO_2	70.21	66.13	48.68	54.03
Al_2O_3	13.95	15.11	14.39	16.71
Fe_2O_3	1.05	2.52	4.00	1.87
FeO	3.08	3.19	10.09	7.70
MgO	1.26	2.42	6.32	5.66
CaO	3.10	1.87	9.23	8.84
Na_2O	3.27	2.71	2.31	2.99
K_2O	2.69	2.86	.47	.67
H_2O-	.19	.24	.46	.14
H_2O+	.48	1.55	2.03	.53
TiO_2	.52	.82	1.69	.84
ZrO_2	Trace.	(?)	(?)	(?)
CO_2	.11	None.	None.	.40
Cr_2O_3	....	....	....	Trace.
MnO	.11	.20	.22	.13
NiO	Trace?	Trace.	Trace.	Trace.
P_2O_5	.10	.22	.29	.13
S	.09	.03	Trace.	.09
BaO	.09	Trace.	Trace.	Trace.
SrO	Trace.	Trace.	None.	Trace.
Li_2O	Trace?	None.	Trace?	Trace?
	100.30	99.87	100.18	100.23

E. Aporhyolite, 1¼ miles north of Ideville, South Mountain, Carlisle quadrangle. *Alaskose.* Contains quartz, orthoclase, perthite, titaniferous magnetite, and hematite.

F. Aporhyolite, west of Green Ridge, South Mountain, Fairfield quadrangle. *Liparose.* Contains quartz, anorthoclase, albite, anorthite, and titaniferous magnetite.

G. Aporhyolite, Marsh Creek Hollow, South Mountain, Fairfield quadrangle. *Alaskose.* Contains quartz, anorthoclase, scanty biotite, and titaniferous magnetite.

H. Metabasalt, west of Green Ridge, South Mountain. *Placerose.* Contains actinolite, chlorite, epidote, quartz, and titaniferous magnetite.

I. Meta-andesite, Gum Spring Road, South Mountain, Fairfield quadrangle. *Placerose.* Contains orthoclase, andesine, chlorite, epidote, and titaniferous magnetite.

Rocks E to I collected by F. Bascom, who supplies the petrographic descriptions. Analyses E, G, I, by W. T. Schaller, record No. 2605. F, H, by G. Steiger, No. 2603.

	E	F	G	H	I
SiO_2	77.13	76.06	75.85	46.79	50.36
Al_2O_3	10.65	11.24	11.39	14.22	17.37
Fe_2O_3	2.85	1.97	3.10	5.10	8.13
FeO	.39	1.36	.40	9.42	4.33
MgO	Trace.	None.	.14	5.86	3.57
CaO	.08	.58	Trace.	10.14	4.29
Na_2O	3.29	2.80	2.73	2.38	4.74
K_2O	4.66	4.95	5.50	.77	.08
H_2O-	.06	.37	.20	.54	.16
H_2O+	.13	.22	None.	2.98	2.73
TiO_2	.22	.30	.30	1.66	3.10
CO_2	.12	None.	.14	None.	Trace.
P_2O_5	Trace.	Trace.	.10	.35	.63
MnO	.33	.20	.01	.18	.24
	99.91	100.05	99.86	100.39	99.73

J. Sericite schist, Pine Grove Furnace, South Mountain. Collected by G. W. Stose and described in Bull. 315, p. 325. Analysis by W. T. Schaller, record No. 2302.

K. Aporhyolite, Monterey, Franklin County. *Kallerudose.* Described by F. Bascom in Bull. 150, p. 343. Contains alkali feldspar, quartz, sericite, epidote, titaniferous magnetite, leucoxene, and rarely sphene. Analysis by H. N. Stokes, record No. 1479. P. R. C. 136.

L. Quartz porphyry, same locality. *Alaskose.* Analyzed for G. H. Williams, but never described. Analysis by L. G. Eakins, record No. 1350.

M. Baltimore gneiss, East Branch of the Brandywine, 2 miles north of Downingtown. *Alaskose.* Contains quartz, microcline, microperthite, plagioclase, ilmenite, and biotite.

N. Quartz diorite, one-half mile north of Devault. *Placerose-tonalose.* Contains plagioclase, quartz, hornblende, zircon, magnetite, and apatite.

O. Granite, north of Black Horse Hill. *Pulaskose.* Contains microperthite, microcline, augite, quartz, and hypersthene, with accessory apatite, zircon, pyrite, and magnetite.

Rocks M, N, O, all from Chester County, were collected by F. Bascom, who supplies the petrographic data. Analyses by R. C. Wells, record No. 2705.

	J	K	L	M	N	O
SiO_2	73.45	76.34	73.85	77.33	64.26	64.64
Al_2O_3	13.77	11.60	13.15	11.47	15.88	15.92
Fe_2O_3	2.76	2.41	3.27	1.47	2.74	1.14
FeO		.30	.36	.27	1.44	4.65
MgO	1.22	.06	.32	.03	2.80	.23
CaO	None.	.55	.82	.19	7.44	2.12
Na_2O	.18	5.50	2.29	3.59	3.43	4.38
K_2O	4.47	2.75	5.42	4.65	.77	6.06
H_2O-	3.08	.10	.71	.18	.15	.04
H_2O+		.39		.52	.50	.43
TiO_2	.21	.26	....	.17	.45	.42
CO_2	....	Trace.	....	....	....	....
ZrO_2	....	....	....	Trace.	.02	Trace.
P_2O_5	.03	Trace.	.06	Trace.	.16	Trace.
S	....	....	....	Trace.	Trace.	.06
MnO	....	Trace.	.09	Trace.	.02	.03
BaO	....	.09	....	.04	None.	.10
	99.17	100.35	100.34	99.91	100.06	100.22

P. Quartz norite, 3 miles east of Aldham Station. *Lassenose-mariposose.* Contains plagioclase, quartz, hypersthene, biotite, magnetite, and apatite.

Q. Gabbro, 1 mile northeast of Fontaine. *Hessose.* Contains labradorite, diallage, augite, magnetite, and apatite.

R. Anorthosite, one-half mile northeast of Forest. *Labradorose.* Contains plagioclase, zoisite, and magnetite.

S. Pyroxenite, one-third mile south of Honeybrook. *Baltimorose.* Contains augite and magnetite, with secondary serpentine.

Rocks P to S, from Chester County, were collected by F. Bascom, who supplies the petrographic data. Analyses by W. T. Schaller, record No. 2723.

	P	Q	R	S
SiO_2	69.10	49.67	52.86	48.62
Al_2O_3	15.05	18.19	26.68	2.66
Fe_2O_3	.74	.33	1.03	6.73
FeO	2.81	12.84	.74	6.88
MgO	1.63	2.12	.38	19.44
CaO	2.86	9.70	10.93	10.29
Na_2O	4.92	2.74	4.44	.20
K_2O	.89	.34	.92	.06
H_2O-	.07	.15	.11	.25
H_2O+	1.76	.74	1.49	3.28
TiO_2	.26	2.01	.25	.57
ZrO_2	Trace.	Trace.	Trace.	None.
CO_2	Trace.	None.	Trace.	Trace.
P_2O_5	.24	.58	.33	.75
S	.08	.32	.05	None.
Cr_2O_3	....	....	....	.46
NiO	....	....	....	.05
MnO	.12	.37	.02	.19
BaO	.02	Trace.	.03	None.
	100.55	100.10	100.26	100.43

MARYLAND AND THE DISTRICT OF COLUMBIA.

1. PERIDOTITE AND PYROXENITE.

Rocks A to I, inclusive, described by G. H. Williams in Am. Geologist, vol. 6, p. 35.

A. Porphyritic lherzolite, Johnny Cake Road, Baltimore County. *SR. 1 of baltimoriase.* Contains olivine, bronzite, and diallage, the olivine partly serpentinized. Analysis by T. M. Chatard, record No. 1094.

B. Websterite, Johnny Cake Road. *Baltimorose.* Consists entirely of hypersthene and diallage. P. R. C. 110 and 1740.

C, D. Alterations of B. *Muricose.* B, C, and D dried at 104°. P. R. C. 1741.

E. Smaragdite rock, altered pyroxenite, Dogwood Road, Baltimore County. *Cecilose.*

Analyses B, C, D, and E by J. E. Whitfield, record Nos. 975, 976. C, D, and E are from the laboratory record and do not appear in the published paper.

	A	B	C	D	E
SiO_2	43.87	50.80	50.10	51.94	53.22
Al_2O_3	1.64	3.40	2.00	2.53	3.14
Fe_2O_3	8.94	1.39	2.38	2.88	....
FeO	2.60	8.11	8.68	9.38	7.95
MgO	27.32	22.77	26.85	25.97	20.09
CaO	6.29	12.31	5.06	3.60	14.44
Na_2O	.50	Trace.	None.	None.	Trace.
K_2O					
H_2O-	1.08	.52	4.16	2.82	.98
H_2O+	7.64				
TiO_2	.12	None.	None.	None.	None.
P_2O_5	Trace.	Trace.	None.	None.	....
Cr_2O_3	.44	.32	.36	.60	.23
NiO	Trace.	....	....	....	....
MnO	.19	.17	.29	Trace.	.11
SO_3	....	Trace.	Trace.	.19	Trace.
Cl	....	.24	.26	.16	.26
	100.63	100.03	100.14	100.07	100.42

F, G. Two samples of websterite, Hebbville, 6 miles west of Baltimore. *Websterose.* P. R. C. 1742.

H. Bronzite from G. P. R. C. 1743.

I. Diopside from G. P. R. C. 1744.

The rock consists entirely of bronzite and diopside. Analyses by T. M. Chatard, record Nos. 1094, 1123.

J. Websterite, Oakwood, Cecil County. *Cecilose.* Composed of hypersthene and diallage. Analysis by W. F. Hillebrand, record No. 1755. Described by A. G. Leonard in Am. Geologist, vol. 28, p. 135.

K. Cortlandtite, Ilchester, Howard County. *Cortlandtose.* Analysis by W. F. Hillebrand, record No. 1422. Published by Williams in 15th Ann., p. 674. The rock consists of olivine, pyroxene, and large hornblende crystals, the latter considerably altered to talc. P. R. C. 1745.

	F	G	H	I	J	K
SiO_2	53.98	52.55	54.53	51.80	53.21	39.20
Al_2O_3	1.32	2.71	1.93	2.21	1.94	4.60
Fe_2O_3	1.41	1.27	1.70	1.29	1.44	3.45
FeO	3.90	4.90	8.92	3.50	7.92	6.15
MgO	22.59	20.39	29.51	17.76	20.78	31.65
CaO	15.47	16.52	2.25	20.99	13.12	3.23
Na_2O	Undet.	.27		Undet.	.11	.42
K_2O	Undet.		....	Undet.	.07	.14
H_2O-	.09	1.09	1.14	.65	.14	.50
H_2O+	.83				.87	9.38
TiO_2	.15	.14	Undet.	.13	.26	.52
P_2O_5	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
ZrO_2	....	....	....	....	Trace.	....
V_2O_3	....	....	....	....	.03	....
Cr_2O_3	.53	.44	.30	.51	.20	.41
NiO	Trace.	....	....	....	.03	.30
CoO	....	....	....	....		....
MnO	.21	.24	.28	Trace.	.22	.20
SrO	....	....	....	....	None.	....
BaO	....	....	....	....	None.	....
Li_2O	....	....	....	....	Trace.	Trace.
FeS_2	....	....	....	....	.03	....
CO_2	....	....	....	....	.10	....
	100.48	100.52	100.56	98.84	100.47	100.15

2. GABBRO AND DIORITE.

Rocks A to E, inclusive, described by G. H. Williams, but not in detail, in 15th Ann., pp. 673, 674. Some of the rocks, with other analyses, are discussed by him in Bull. 28. Analyses by W. F. Hillebrand, record No. 1422.

A. Olivine gabbro, Orange Grove, Baltimore County. *IV*. 1^2. 1^3. *2*. Contains plagioclase, diallage, hypersthene, fresh olivine, magnetite, and apatite, and sometimes hornblende. P. R. C. 1746.

B. Hypersthene gabbro, Wetheredville, Baltimore County. *Kedabekose.* Rich in hypersthene and diallage, with plagioclase, magnetite, and apatite. P. R. C. 1747.

C. Gabbro diorite, Ilchester, Howard County. *Hessose.* A coarse anorthite-hornblende rock, probably an altered gabbro. P. R. C. 1748.

D. Biotite diorite, Triadelphia, Montgomery County. *Bandose.* P. R. C. 1749.

E. Biotite diorite, Georgetown, D. C. *Bandose.* P. R. C. 1750.

To these may be added an analysis made for Williams by L. G. Eakins, record No. 1350, as follows.

F. Hornblende diorite, Rock Creek tunnel shaft, Washington, D. C. *III. 4. 4. 4. 5.* Relations to E not stated.

	A	B	C	D	E	F
SiO_2	48.91	44.76	43.42	55.97	56.41	56.18
Al_2O_3	8.81	18.82	22.37	15.60	15.19	14.76
Fe_2O_3	1.04	2.19	.81	1.21	1.60	2.12
FeO	9.52	4.73	9.25	6.28	6.24	6.98
MgO	15.19	11.32	5.75	6.83	7.18	8.11
CaO	14.69	14.58	13.34	7.31	6.77	7.97
Na_2O	.64	.89	1.24	2.23	2.21	1.62
K_2O	.10	.11	1.13	1.25	1.34	.80
H_2O-	.07	.17	.09	.18	.08	1.37
H_2O+	.52	2.36	1.54	1.85	2.00	
TiO_2	.37	.13	1.25	1.11	.69	....
P_2O_5	Trace.	None.	.10	.16	.05	.08
SnO_2, ZrO_2 ?	....	....	....	....	.14	....
Cr_2O_3	.15	.08	Trace.	.04	.05	....
MnO	.16	.15	.06	.08	.11	.17
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.	....
	100.17	100.29	100.35	100.10	100.06	100.16

The following rocks, from Cecil County, are described by A. G. Leonard in Am. Geologist, vol. 28, p. 135.

G. Quartz-mica-hornblende diorite, near the foundry on Stone Run. *Bandose.* Contains hornblende, biotite, quartz, plagioclase, and a little orthoclase, with accessory zircon, apatite, titanite, and magnetite, and secondary chlorite and epidote.

H. Like G, near Porter's Bridge on Octoraro Creek. *Bandose.*

I. Hornblende diorite poor in quartz, three-fourths mile northwest of Rising Sun. *Corsose.*

J. Norite, 1 mile west of Oak Grove schoolhouse. *Kedabekose.* Contains hypersthene, bytownite, a little diallage, apatite, magnetite, and secondary hornblende.

Analyses by Hillebrand, record No. 1755.

	G	H	I	J
SiO_2	58.57	55.16	44.04	48.02
Al_2O_3	16.10	17.51	20.01	20.01
Fe_2O_3	2.89	2.62	4.22	1.13
FeO	6.12	5.83	8.61	7.29
MgO	2.33	4.35	5.01	10.05
CaO	7.39	8.50	11.68	11.42
Na_2O	2.11	1.83	1.24	.51
K_2O	1.01	1.08	.15	.05
H_2O-	.21	.18	.11	.10
H_2O+	1.27	2.01	1.90	.57
TiO_2	1.41	.64	2.24	.23
P_2O_5	.37	.21	.52	Trace.
ZrO_2	.09	.02	.10	None.
V_2O_3	.02	.04	.05	.02
Cr_2O_3	None.	Trace.	None.	.03
NiO, CoO	None.	.01	.01	.01
MnO	.18	.15	.28	.18
SrO	Trace.	Trace.	None.	None.
BaO	Trace.	Trace.	None.	None.
Li_2O	Trace.	Trace.	Trace.	Trace.
FeS_2	Trace.	.03	.25	.11
CO_2	None.	None.	None.	.25
	100.07	100.17	100.42	99.98

3. GRANITE AND GNEISS.

For descriptions see Williams, 15th Ann., p. 657, and Keyes, idem, p. 685. The Rowlandsville granite is described by Grimsley in Jour. Cincinnati Soc. Nat. Hist., vol. 17, p. 78.

A. White granite, Brookville, Montgomery County. *Liparose.* (Williams.) P. R. C., 1751.

B. Binary granite, Guilford, Howard County. *Toscanose.* Contains quartz, orthoclase. a little plagioclase, muscovite, and biotite, with occasional zircon and apatite. (Keyes.)

C. Biotite granite, Woodstock. *Toscanose.* Light colored, fine grained. Quartz, feldspar, and biotite, with accessory allanite and epidote. (Keyes.)

D. Biotite granite, Rowlandsville, Cecil County. *Tonalose.* Dark colored. Contains plagioclase, orthoclase, quartz, epidote, biotite, sphene, magnetite, and apatite, with a little secondary muscovite. The percentages of the several minerals are computed by Grimsley from the analysis.

Analyses by W. F. Hillebrand, record Nos. 1220, 1422, 1455. In B and C manganese was present, barium and strontium were not tested for, and the alumina contains possible titanium and phosphoric acid.

	A	B	C	D
SiO_2	74.87	72.57	71.79	66.68
Al_2O_3	14.27	15.11	15.00	14.93
Fe_2O_3	Trace.	.59	.77	1.58
FeO	.51	1.02	1.12	3.32
MgO	.16	.30	.51	2.19
CaO	.48	1.65	2.50	4.89
Na_2O	3.06	3.92	3.09	2.65
K_2O	5.36	4.33	4.75	2.05
H_2O-	.26	.47	.64	.16
H_2O+	.66			1.09
TiO_2	.05	Undet.	Undet.	.50
P_2O_5	.21	Undet.	Undet.	.10
MnO	Trace.	Undet.	Undet.	.10
SrO	....	Undet.	Undet.	Trace.
BaO	....	Undet.	Undet.	.08
Li_2O	Trace.	Trace.	Trace.	Trace.
	99.89	99.96	100.17	100.32

E. Biotite granite, Dorseys Run, Howard County. *Yellowstonose.* Typical, dark colored. Quartz, feldspar, and biotite, with accessory allanite and epidote. (Keyes.) P. R. C. 1752.

F. Same locality, light-colored dikes. *Toscanose.*

G. Inclusions in E. *SR. 2 of tonalase.* Derived from gneiss.

H. The typical gneiss of the Dorseys Run area. Perhaps of sedimentary origin.

Description by Keyes. Analyses by Hillebrand. The remarks appertaining to B and C apply here also. Record No. 1220.

	E	F	G	H
SiO_2	62.91	70.45	57.33	48.92
Al_2O_3	19.13	15.98	15.31	16.57
Fe_2O_3	.98	.75	3.39	4.21
FeO	3.20	1.84	8.19	9.18
MgO	1.69	.77	4.36	5.98
CaO	4.28	2.60	3.95	9.69
Na_2O	3.94	3.83	1.22	2.47
K_2O	3.38	3.59	4.57	1.56
H_2O	.63	.45	1.80	1.68
Li_2O	Trace.	Trace.	Trace.	Trace.
	100.14	100.26	100.12	100.26

I. Biotite granite, Sykesville. *Tehamose.* Contains quartz, feldspar, and biotite, with accessory magnetite, zircon, and apatite.

J. Inclusion in I, derived from limestone. Yellowish central portion. Consists of epidote and quartz, with a little chlorite.

K. Same inclusion, fine-grained dark outer zone. Quartz, garnet, and epidote, with a little magnetite. Feldspar and muscovite in some portions. Descriptions by Keyes. Analyses by Hillebrand, record No. 1220, with the same limitations as in the Guilford, Woodstock, and Dorseys Run granites.

	I	J	K
SiO_2	71.45	67.02	47.35
Al_2O_3	14.36	13.77	29.76
Fe_2O_3	2.07	4.64	2.94
FeO	2.78	1.02	3.15
MgO	1.17	.65	1.60
CaO	1.58	11.09	2.20
Na_2O	1.95	.66	2.84
K_2O	3.28	.09	6.83
H_2O	1.30	1.16	3.15
Li_2O	Trace.	Trace.	Trace.
	99.94	100.10	99.82

L. Typical gneiss of Washington, D. C., from quarry of Potomac Stone Co., 1 mile below Chain Bridge. A "basic" granite.

M. Fine-grained, fissile chloritic gneiss, from northwest of Cabin John Bridge. Also a "basic" granite. P. R. C. 1753.

N. Fine-grained, hard gneiss, from the second lock at the Great Falls of the Potomac. *Alsbachose*. Probably of sedimentary origin.

Described by Williams. Analyses by Hillebrand, record No. 1459.

	L	M	N
SiO_2	67.22	63.43	78.28
Al_2O_3	15.34	16.69	9.96
Fe_2O_3	2.78	3.36	1.85
FeO	3.41	3.87	1.78
MgO	1.65	2.33	.95
CaO	1.36	.80	1.68
Na_2O	2.00	2.38	2.73
K_2O	3.26	3.22	1.35
H_2O-	.29	.23	.12
H_2O+	1.68	2.67	.83
TiO_2	.84	.91	.70
P_2O_5	.14	.11	.11
MnO	.13	.09	.08
SrO	Trace.	Trace.	Trace.
BaO	.04	.03	.02
Li_2O	Trace.	Trace.	Trace.
	100.14	100.12	100.44

4. MISCELLANEOUS ROCKS.

A. Typical diabase, Rocky Ridge. *Auvergnose*. Analyzed for J. S. Diller but not described. Analysis by E. A. Schneider, record No. 1370.

B. Ottrelite-phyllite rock, Liberty, Frederick County. Analyzed for G. H. Williams but not described. P. R. C. 1754.

C. Chloritoid separated from B. Analyses B and C by L. G. Eakins, record No. 1349.

D. Quartz schist, Shoemaker quarry, near Stevenson Station, Green Spring Valley. Described by Bayley in Bull. 150, p. 302. Contains quartz, muscovite, occasional tourmalines, microcline, zircon, and iron stains. Analysis by Schneider, No. 1370. P. R. C. 119.

E. Mica separated from D. Analysis by Schneider, No. 1377.

	A	B	C	D	E
SiO_2	51.68	34.92	23.40	91.65	44.93
Al_2O_3	15.87	32.31	30.31	1.59	29.81
Fe_2O_3	1.46	10.21	5.14	3.57	6.10
FeO	8.43	8.46	21.94	.21	
MgO	7.84	1.13	2.18	.17	1.16
CaO	11.08	.36	Trace.	None.	....
Na_2O	1.86	2.12	.20	.07	.50
K_2O	.34	1.87	.20	1.93	10.28
H_2O-	.16	5.29	6.81	....	1.38
H_2O+	.15			.60	4.88
TiO_2	.72	3.37	1.19	.13	1.06
P_2O_5	.12	.23	Trace.	None.	....
MnO	.15	Trace.	Trace.	Trace.	Trace.
Li_2O	....	....	....	....	Trace.
F	....	....	....	....	.22
	99.86	100.27	100.37	99.92	100.31

F. Sericite schist, Ladiesburg. Described by Bayley in Bull. 150, p. 317. Contains quartz, sericite, chlorite, a mineral thought to be kaolin, zircon, iron oxide, and rutile. Analysis by George Steiger, record No. 1600. P. R. C. 126.

G. Another sample of F. Analysis by Schneider, No. 1370.

H. Metarhyolite, south of Port Deposit. Dike. *Vulcanose.* Described by F. Bascom, in Maryland Geological Survey, Cecil County volume, p. 136. Contains quartz, orthoclase, plagioclase, biotite, and hornblende, with accessory magnetite, apatite, titanite, garnet, pyrrhotite, and muscovite, and secondary chlorite and epidote. Analysis by W. F. Hillebrand, record No. 1928. P. R. C. 1706.

	F	G	H
SiO_2	57.24	58.11	75.67
Al_2O_3	23.48	21.84	12.28
Fe_2O_3	3.19	2.62	[a] .85
FeO	4.87	5.63	[a] 2.59
MgO	.93	1.85	.37
CaO	.09	None.	2.65
Na_2O	1.18	.97	3.63
K_2O	3.55	3.66	.78
H_2O-	.33	.35	.12
H_2O+	4.65	4.05	.29
TiO_2	.08	.81	.29
P_2O_5	.09	.21	.05
MnO	None.	.19	.18
SrO	....	....	Trace?
BaO	....	....	.07
CO_2	....	....	Trace.
S	....	....	.11
	99.68	100.29	99.93

[a] Uncertain because sulphides are present.

VIRGINIA.

A. Andesite, 3½ miles east of Front Royal. *SR. 4 of orendase.* Described by Keith in 14th Ann., p. 305. Intermediate between diabase and quartz porphyry. Contains plagioclase, quartz, magnetite, ilmenite, and a little epidote. Analysis by George Steiger, record No. 1450.

B. Porphyritic felsite or felsophyre, forks of Straight Creek, 3 miles east-northeast of Monterey. *Toscanose.* Described by Darton and Keith in Am. Jour. Sci., 4th ser., vol. 6, p. 305. Contains phenocrysts of biotite, orthoclase, and plagioclase, the mica and feldspar being about equal in amount In the groundmass are feldspar, quartz, magnetite, or ilmenite, and a little secondary chlorite, with less muscovite. No glass. Analysis by Hillebrand, record No. 1665. P. R. C. 342.

	A	B
SiO_2	51.08	69.56
Al_2O_3	11.37	15.52
Fe_2O_3	11.17	1.67
FeO	5.64	1.19
MgO	3.96	.41
CaO	5.20	1.20
Na_2O	5.54	4.46
K_2O	1.50	4.68
H_2O-	1.31	.34
H_2O+	.19	.67
TiO_2	2.67	.31
P_2O_5	.39	.08
MnO	.22	.07
SrO	....	Trace.
BaO	....	.10
Li_2O	....	Trace.
CO_2	....	None.
Cl, F	....	(?)
S	....	Trace.
	100.24	100.26

NORTH CAROLINA.

Rocks A to F collected by Arthur Keith, who furnishes the petrographic data. Analyses B, C, D, and E by W. F. Hillebrand, record No. 1707. Analyses A and F by H. N. Stokes, record No. 1710.

A. Porphyritic rhyolite, 2 miles west of Barmers Elk, Watauga County. *Adamellose.* Contains orthoclase and plagioclase, with less quartz, epidote, chlorite, and pyrite.

B. Quartz porphyry, 2½ miles northwest of Blowing Rock, Watauga County. *Magdeburgose.* Contains quartz and orthoclase, with subordinate sericite, chlorite, and biotite.

C. Diorite, east end of Hump Mountain, Mitchell County. *Auvergnose.* Contains plagioclase, orthoclase, and hornblende, with less quartz, biotite, magnetite, and garnet.

D. Garnetiferous diabase, 1¾ miles southeast of Cranberry. *III. 4. 4. 4. 5.* Contains plagioclase and hornblende, with less garnet, biotite, and magnetite.

	A	B	C	D
SiO_2	62.35	79.75	46.91	52.11
Al_2O_3	13.24	10.47	15.85	13.70
Fe_2O_3	3.52	.64	2.86	1.22
FeO	6.33	.92	9.95	9.86
MgO	.85	.13	7.01	8.08
CaO	3.34	.15	9.62	12.16
Na_2O	2.79	1.36	2.65	1.31
K_2O	3.95	6.01	.69	.16
H_2O-	.11	.08	.24	.06
H_2O+	1.21	.60	1.62	.53
TiO_2	1.18	.15	2.03	.32
P_2O_5	.57	Trace.	.26	.05
ZrO_2	....	.05	None.	None.
Cr_2O_3	None.	....	.01	....
V_2O_3	....	....	.03	....
CoO, NiO	None.	None.	.03	.03
MnO	.08	Trace.	.22	.20
SrO	Trace.	Trace.	Trace?	None.
BaO	.16	.06	Trace?	None.
Li_2O	Trace.	Trace.	Trace.	Trace.
S	....	None.	None.	Trace.
	99.68	100.37	99.98	99.79

E. Epidote-chlorite schist, one-fourth mile northeast of Montezuma, Mitchell County. Contains epidote and feldspar, with less chlorite, hornblende, and magnetite.

F. Metamorphosed amygdaloid, 3 miles southeast of Boone, Watauga County. Contains orthoclase and plagioclase, with less sericite, chlorite, and magnetite.

G. Pyroxenite, var. websterite, from Webster. *Websterose.* Described by Williams, Am. Geologist, vol. 6, p. 35. Consists of diopside and bronzite. Analysis by E. A. Schneider, record No. 1096. Material dried at 105°. P. R. C. 388.

H. Spherulitic rhyolite, Sam Christian gold mine, Montgomery County. *Alaskose.* Described by Diller, Am. Jour. Sci., 4th ser., vol. 7, p. 337. The rock of the supposed fossil *Palæotrochis.* Contains feldspar and quartz, with a little biotite and sericite. Analysis by Hillebrand, record No. 1796.

	E	F	G	H
SiO_2	47.85	43.62	55.14	79.57
Al_2O_3	16.51	17.30	.66	11.41
Fe_2O_3	4.16	14.13	3.48	.20
FeO	7.43	6.83	4.73	.70
MgO	6.24	2.34	26.66	A little.
CaO	7.00	1.63	8.39	.21
Na_2O	3.20	3.45	.30	3.46
K_2O	.82	3.03		3.52
H_2O-	.21	.30	.38	.18
H_2O+	4.00	2.93		.61
TiO_2	2.28	2.75	Trace.	.11
P_2O_5	.35	1.34	1.23	Trace.
ZrO_2	.03			
Cr_2O_3	.01	None.	.25	
V_2O_3	.05			
CoO, NiO	.03	None.	.11	
MnO	.24	Trace.	.03	None.
SrO	Trace.	Trace.		
BaO	Trace.	.09		.05
Li_2O	Trace.	Trace.		
	100.41	99.74	100.36	100.02

The following rocks from Corundum Hill were collected, analyzed, and described by T. M. Chatard, Bull. 42, p. 45:

I. Altered gneiss. Made up of micaceous scales, with grains of quartz and some earthy matter. Record No. 238.

J. Dunite. *Dunose.* Olivine rock containing a little chromite. Record No. 256.

K, L. Yellow, claylike alterations of dunite. Record Nos. 254, 255.

Other analyses of altered rocks are given in the paper, and also analyses of associated minerals.

	I	J	K	L
SiO_2	64.27	40.11	40.18	40.04
Al_2O_3	16.75	.88	1.35	3.17
Fe_2O_3	6.08	1.20	10.97	12.15
FeO	.89	6.09		
MgO	1.74	48.58	43.84	42.97
CaO	.25			
Na_2O	.89			
K_2O	3.09			
H_2O, ignition	4.97	2.74	2.01	2.14
TiO_2	1.32		None.	None.
P_2O_5	.05			
Cr_2O_3		.18	1.41	
MnO	.07			
Chromite		.56		.17
	100.37	100.34	99.76	100.64

GEORGIA.

Rocks collected by A. H. Brooks, who supplies the petrographic data. Analyses by H. N. Stokes. Record No. 1727.

A. Meta-quartz diorite, 2 miles southwest of Sweden, Gordon County. *Gordonose.* Contains plagioclase, near labradorite, green hornblende, sometimes diallage, much vitreous quartz, and accessory magnetite, ilmenite, and orthoclase. Also secondary epidote, zoisite, uralite, chlorite, garnet, calcite, and leucoxene. P. R. C. 1530.

B. Augite-microcline granite, 1 mile east of Rowland, Bartow County. *Toscanose.* Contains microcline, some plagioclase, abundant pyroxene partly altered into chiefly uralite and chlorite, some biotite with frequent inclusions of rutile, much blue vitreous quartz, apatite, zircon, and magnetite. P. R. C. 1531.

C. Quartz gabbro, 2 miles southeast of Walleska, Cherokee County. *Harzose.* Closely related to B. Contains essentially plagioclase, near labradorite, and augite. Accessory magnetite, ilmenite, apatite, and zoisite. Orthoclase is sparingly present. Quartz occurs in vitreous masses. P. R. C. 1532.

	A	B	C
SiO_2	69.87	67.98	56.20
Al_2O_3	12.02	14.84	15.46
Fe_2C_3	1.42	1.00	1.54
FeO	3.49	3.15	9.76
MgO	2.30	.91	1.83
CaO	7.86	2.17	5.39
Na_2O	.66	2.66	2.78
K_2O	.11	4.76	2.56
H_2O-	.18	.14	.16
H_2O+	.89	.49	.59
TiO_2	.69	.84	2.25
P_2O_5	.17	.34	1.13
MnO	.16	Trace.	.13
BaO	None.	.20	.17
SrO	None.	Trace.	Trace.
Li_2O	Trace.	Trace.	None.
CO_2	.43	None.	None.
S	None.	.08	.07
SO_3	None.	Trace.	Trace.
Cl	None.	Trace.	Trace.
F	(?)	Trace.	Trace.
C (graphite)	....	.21	....
	100.25	99.77	100.02

KENTUCKY.

1. ELLIOTT COUNTY DIKE.

Described by Diller in Bull. 38. Also in Am. Jour. Sci., 3d ser., vol. 32, p. 125.

A peridotite, var. kimberlite, consisting largely of olivine, sometimes altered to serpentine. Pyrope, ilmenite, a few scales of biotite, a little enstatite, and a trace of apatite are present as primary minerals. Secondary minerals are serpentine, dolomite, magnetite, and octahedrite.

A granitic rock occurs with the peridotite. It consists chiefly of feldspar, orthoclase, and plagioclase, with a considerable amount of quartz and ilmenite, and traces of hornblende, sphene, and apatite.

Analyses by T. M. Chatard, record Nos. 272, 273, 282, 305, 351, 352, 353, 354, and 358.

A. Granite. *Monzonose.*

B. Peridotite (kimberlite). P. R. C. 799.

C. Olivine from peridotite.

D. Garnet from peridotite.

E. Ilmenite from peridotite.

	A	B	C	D	E
SiO_2	60.56	29.81	40.05	41.32	0.76
Al_2O_3	16.19	2.01	.39	21.21	2.84
Fe_2O_3	5.19	5.16	2.36	4.21	9.13
FeO	2.41	4.35	7.14	7.93	27.81
MgO	1.30	32.41	46.68	19.32	8.68
CaO	2.09	7.69	1.16	4.94	.23
Na_2O	4.78	.11	.08	.07	.19
K_2O	4.82	.20	.21	....	
H_2O	....	8.92	.14	.17	.20
H_2O, ignition	.51		.66		
TiO_2	1.19	2.20	.07	.16	49.32
P_2O_5	.30	.35	.04	None.	Trace.
Cr_2O_3	....	.43	.24	.91	.74
MnO	.36	.23	.20	.34	.20
NiO	....	.05	....	....	....
CoO	....	....	Trace.	....	....
CO_2	....	6.66	(?)	....	....
SO_3	....	.28	....	....	....
	99.70	100.86	99.42	100.58	100.10

2. CRITTENDEN COUNTY DIKE.

A mica peridotite, described by Diller in Am. Jour. Sci., 3d ser., vol. 44, p. 286. Contains biotite, serpentine, and perofskite, with less apatite, muscovite, magnetite, calcite, chlorite, and some other secondary products. P. R. C. 800.

A. The rock described by Diller. *ŞR. 1 of casseliase.* Analysis by W. F. Hillebrand, record No. 1241.

B. An analysis of probably the same rock, from a shaft 40 feet deep at Marion. Collected by J. R. Procter, analyzed by L. G. Eakins, record No. 965.

	A	B
SiO_2	33.84	34.50
Al_2O_3	5.88	14.37
Fe_2O_3	7.04	2.85
FeO	5.16	4.46
MgO	22.96	21.81
CaO	9.46	11.43
Na_2O	.33	.51
K_2O	2.04	1.50
H_2O	7.50	7.14
TiO_2	3.78	....
P_2O_5	.89	.77
Cr_2O_3	.18	....
MnO	.16	....
NiO	.10	....
CoO	Trace.	....
BaO	.06	....
Cl	.05	....
CO_2	.43	.21
SO_3	....	.60
	99.86	100.15

TENNESSEE.

The following rocks, A to H, were collected by W. H. Emmons in or near Ducktown. They represent the associates of the copper ores.

A. Quartz diorite. Central portion of mass, Burra Burra mine. Sp. Gr. 2.781.

B. Quartz diorite. Marginal portion. Sp. gr. 2.800.

C. Quartz biotite schist inclosing quartz diorite. Contains secondary actinolite, zoisite, and garnet. Sp. gr. 2.739. Analyses A, B, C, by G. Steiger, record No. 2513.

D. Metamorphosed quartz diorite. Contains quartz, orthoclase, plagioclase, actinolite, zoisite, biotite, and garnet. Sp. gr. 2.81. Analysis by W. T. Schaller, record No. 2537.

	A	B	C	D
SiO_2	51.90	71.63	73.90	75.35
Al_2O_3	10.72	11.40	11.94	10.66
Fe_2O_3	.45	.83	.38	.49
FeO	2.03	3.72	3.72	3.03
MgO	.43	1.28	1.34	1.17
CaO	18.87	6.36	3.09	5.37
Na_2O	2.12	2.38	2.84	1.79
K_2O	None.	None.	1.08	.20
H_2O-	.10	.03	.16	Trace.
H_2O+	.67	.74	.90	.61
TiO_2	.67	.61	.65	.33
ZrO_2				.02
CO_2	11.34	.68	.14	.28
P_2O_5	.17	.12	.12	.10
S	None.	None.	.08	
FeS_2				.06
MnO	.38	.23	.10	.14
BaO				Trace.
SrO				Trace?
	99.85	100.01	100.44	99.60

E. Garnetiferous rock, Mary mine. Sp. gr. 3.61. Analysis by Chase Palmer, record No. 2524.

F. Schist, East Tennessee mine. Sp. gr. 2.737. Analysis by Palmer, No. 2524.

G. Metamorphosed arkose sandstone, East Tennessee mine. Contains quartz, some feldspar, black and white mica, and particles of sulphides. Sp. gr. 2.75. Analysis by Schaller, No. 2537.

H. Actinolite rock with sulphides, Polk County mine. Analysis by R. C. Wells, No. 2515. Sp. gr. 3.190.

	E	F	G	H
SiO_2	33.40	72.94	76.10	46.78
Al_2O_3	13.52	12.38	8.74	8.20
Fe_2O_3	8.98	.25		13.86
FeO		3.80	[a]3.54	
MgO	1.17	1.38	4.27	11.41
CaO	24.06	2.43	1.33	12.16
Na_2O	.17	2.52	1.12	.41
K_2O	.32	1.35	.48	.20
H_2O-	None.	None.	.09	.18
H_2O+	.35	.84	1.64	1.72
TiO_2	.07	.67	.29	.51
CO_2	5.28		.50	
P_2O_5	.17	.16	.11	None.
SO_3		.83		
S				4.87
FeS_2	11.55		1.61	
MnO	1.23	.23	.11	.60
CuO	.10	.19		
Cu				.24
Zn				.17
Pb				Trace.
	100.37	99.97	99.93	101.31
Less O				2.43
				98.88

[a] Uncertain, because of sulphides present.

Rocks I to N, also from the Ducktown quadrangle, were collected by F. B. Laney, who supplies the petrographic data.

I. White border of pseudodiorite. Contains quartz, orthoclase, plagioclase, biotite, zoisite, garnet, pyrrhotite, titanite, magnetite, and ilmenite.

J. Graywacke. Contains quartz, orthoclase, albite, biotite, garnet, pyrrhotite, magnetite, ilmenite.

Analyses I, J, by Chase Palmer, record No. 2814.

K. Graywacke. Contains quartz, plagioclase, orthoclase, biotite, titanite, and pyrrhotite.

L. Graywacke. Contains quartz, plagioclase, biotite, orthoclase, chlorite, garnet, and pyrrhotite.

Analyses K, L, by J. G. Fairchild, record No. 2544.

M. Gabbro, near Copper Hill. *III. 5. 2. 5.* Contains hornblende, zoisite, plagioclase, quartz, epidote (?), titanite, and pyrite.

N. Pseudodiorite from mine No. 20, Copperfield. Contains quartz, hornblende, garnet, plagioclase, zoisite, titanite, pyrrhotite, and pyrite.

Analyses M, N, by Palmer, No. 2552.

	I	J	K	L	M	N
SiO_2	78.86	76.01	74.50	74.81	49.62	67.11
Al_2O_3	11.27	10.98	13.29	12.72	15.87	15.44
Fe_2O_3	.53	.37	Trace.	.65	1.75	.89
FeO	1.11	3.35	3.64	3.64	7.90	3.89
MgO	.27	.28	2.06	2.29	7.29	.19
CaO	4.27	3.21	None.	None.	12.86	6.79
Na_2O	2.51	2.76	1.74	3.30	2.17	2.58
K_2O	.44	1.32	4.42	1.72	.40	.41
H_2O-	.20	None.	.04	None.	.27	.03
H_2O+	.14	.51	.22	.48	1.59	.70
TiO_2	.45	.50	.70	.70	.58	.34
P_2O_5	.12	.10	.22	.13	.11	.26
S	.29	.31	.16	.13	....	....
SO_3	....	....	....	....	.08	.13
MnO	.02	.55	.05	.07	.20	.43
	100.48	100.25	101.04	100.64	100.69	99.19

O. Gabbro, 2 miles south of Limestone Cove, Unicoi County. *Camptonose.* Collected by Arthur Keith, who furnishes the petrographic data. Analysis by W. F. Hillebrand, record No. 1707. Contains hypersthene, plagioclase, and magnetite.

SiO_2	48.11	P_2O_5	0.44
Al_2O_3	14.74	ZrO_2	(?)
Fe_2O_3	2.54	Cr_2O_3	.01
FeO	11.85	V_2O_3	.03
MgO	5.10	NiO, CoO	.03
CaO	6.72	MnO	.19
Na_2O	2.92	SrO	.02
K_2O	1.92	BaO	.04
H_2O-	.27	Li_2O	Trace.
H_2O+	1.73	FeS_2	[a] .13
TiO_2	3.17		99.96

MISSOURI.

Rocks A to D, granite and porphyry, 6 miles east of Ironton. Described by Haworth in Missouri Geol. Survey, vol. 8, Annual Report. pp. 140, 180, and 213. Analyses by W. H. Melville, record No. 1206.

A, B. Granite. A, P. R. C. 1027; B, P. R. C. 1028.

C, D. Porphyry. C, P. R. C. 1029; D, P. R. C. 1030.

Rocks composed principally of orthoclase and quartz, with some microcline, plagioclase, and biotite, and minor accessory minerals. A is *toscanose;* B, C, and D are *liparose.*

E. Devonite, Mount Devon. Groundmass only. Collected and described by A. Johannsen. Contains phenocrysts of a plagioclase rich in potassium. The groundmass consists of feldspar and augite, with titaniferous magnetite and chlorite. Analysis by W. F. Hillebrand, record No. 2350.

---

[a] Equivalent to 0.07 S. Assumed to be pyrite, as no pyrrhotite is present.

	A	B	C	D	E
SiO_2	69.94	72.35	71.33	71.88	46.88
Al_2O_3	15.19	13.78	12.55	12.88	17.27
Fe_2O_3	1.88	1.87	3.75	3.05	2.47
FeO	.60	.36	.85	1.05	8.84
MgO	.92	.42	.58	.33	6.73
CaO	1.15	.87	.94	1.13	8.65
Na_2O	3.95	4.44	4.52	4.21	2.51
K_2O	4.29	4.49	4.20	4.46	1.25
H_2O-	.14	.22	.12	.17	.28
H_2O+	.85	.54	.30	.26	3.30
TiO_2	.25	.44	.55	.22	1.64
P_2O_5	.13	.13	.16	.15	.35
S					A little.
MnO	.03	.06	.04	Trace.	.15
NiO	Trace.	.20	.15	.02	
BaO					A little.
SrO, Li_2O					(??)
Cr_2O_3					Trace?
	99.32	100.17	100.04	99.81	100.32

ARKANSAS.

Ouachitite, dike near Maple Spring, 4 miles southwest of Hot Springs. *SR. 2 of etindase.* Described by Kemp, in Ann. Rept. Geol. Survey Arkansas, 1890, vol. 2, p. 399. A dike rock of the monchiquite group. Contains abundant and conspicuous augite and biotite, magnetite, and minor accessory minerals in a groundmass considered by Kemp to be glass. Calcite and other secondary products are also present. According to Pirsson, Jour. Geology, vol. 4, p. 679, the so-called "glass" in the monchiquites is really analcite. Analysis by L. G. Eakins, record No. 1023. P. R. C. 395.

SiO_2	36.40	K_2O	3.01
Al_2O_3	12.94	H_2O	2.36
Fe_2O_3	8.27	TiO_2	.42
FeO	4.59	P_2O_5	1.04
MgO	11.44	CO_2	3.94
CaO	14.46		
Na_2O	.97		99.84

OKLAHOMA.

A. Granite, west of Mount Sheridan, Wichita Mountains, *Liparose*, received from J. P. Iddings. Analysis by G. Steiger, record No. 2335.

B. Hornblende granite, Mountain Park. *Liparose.* P. R. C. 1890.

C. Hornblende granite, Cold Springs. *Dacose.* P. R. C. 1891.

Rocks B, C, collected by C. H. Taylor. Analyses by J. G. Fairchild, record No. 2676.

	A	B	C
SiO_2	73.61	74.14	63.04
Al_2O_3	11.97	12.97	14.30
Fe_2O_3	2.34	1.07	1.25
FeO	1.51	1.20	6.12
MgO	.19	Trace.	1.75
CaO	1.38	.48	4.38
Na_2O	3.76	4.61	3.57
K_2O	4.32	5.30	3.17
H_2O-	.32	.12	.05
H_2O+	.35	.19	.72
TiO_2	.46	.25	1.43
ZrO_2	None.		
CO_2	None.		
P_2O_5	.15	Trace.	.28
S		Trace.	.04
MnO	.09	.03	.09
BaO	.04		
SrO	.02		
	100.51	100.38	100.19

TEXAS.

A. Quartz pantellerite, Vieja Mountains, San Carlos, Presidio County. *Liparose.* Description furnished by E. C. E. Lord. Contains anorthoclase, augite, and grains of quartz in a groundmass of ægirine-augite, a brown hornblende which is probably barkevikite, orthoclase, and quartz. Magnetite and apatite are present as accessory minerals. Analysis by George Steiger, record No. 1581.

The following rocks, analyses B to M, from Uvalde County, were collected by T. Wayland Vaughan. Petrographic data furnished by Whitman Cross. Analyses by W. F. Hillebrand, record No. 1681.

B. Plagioclase basalt, Pinto Mountain, Brackett quadrangle. *Limburgose.* Contains olivine, augite, plagioclase (labradorite), biotite, a very little alkali feldspar (?), magnetite, and apatite. Sp. gr., 3.118, 20°. P. R. C. 1067.

C. Basanite, Mount Inge, Uvalde quadrangle. *Lujavrose.* Contains sanidine, nephelite, hornblende, augite, ægirine-augite, olivine, magnetite, apatite, and a trace of pyrite. Sp. gr., 2.770, 20°. P. R. C. 1069.

D. Rock of basaltic habit, allied to C, 1 mile northeast of Big Mountain, Uvalde quadrangle. *Essexose.* Contains alkali feldspar, augite, magnetite, and variable amounts of olivine, nephelite, ægirite, biotite, and zeolitic minerals. Sp. gr., 2.742, 23°. P. R. C. 1068.

	A	B	C	D
SiO_2	68.71	45.11	48.13	48.23
Al_2O_3	13.45	[a] 12.44	18.44	17.43
Fe_2O_3	5.31	2.67	3.41	2.77
FeO	.75	9.36	4.30	5.92
MgO	.19	11.56	3.06	2.99
CaO	.96	10.61	5.89	6.38
Na_2O	4.63	3.05	8.00	6.87
K_2O	5.51	1.01	3.80	2.78
H_2O-	.13	.16	.18	.54
H_2O+	.36	.78	1.59	2.84
TiO_2	.21	2.34	1.74	2.00
P_2O_5	.04	.51	.49	.69
ZrO_2	....	(?)	.05	.04
Cr_2O_3	....	....	None.	None.
V_2O_3	....	.04	....	.04
NiO	....	.04	.02	Trace.
MnO	.14	.22	.19	.18
SrO	None.	Trace.	.10	.08
BaO	None.	Trace.	.10	.08
Li_2O	None.	None.	Trace.	Trace.
S	....	.01	.09	.08
SO_3	.05	....	....	....
Cl	....	.11	.29	.03
F	....	Undet.	.06	Undet.
	100.44	100.02	99.93	99.97
Less O	....	.02	.09	....
	....	100.00	99.84	....

[a] Including Cr_2O_3.

E. Phonolite, hill between Black and Big mountains, Uvalde quadrangle. *Laurdalose.* Contains sanidine, nephelite, and ægirite, and very little brown hornblende, augite, and magnetite. Sp. gr. 2.559, 19.5°. P. R. C. 1070.

F. The portion of E soluble in 1:40 dilute nitric acid.

G. Nepheline basalt, Tom Nunns Hill, Uvalde quadrangle. *Uvaldose.* Contains olivine, augite, nephelite, magnetite, and apatite. Sp. gr., 3.148, 19°. P. R. C. 1065.

H. The portion of G soluble in 1:40 dilute nitric acid.

	E	F	G	H
SiO_2	54.42	26.90	40.32	12.27
Al_2O_3	20.76	14.34	[a]9.46	6.09
Fe_2O_3	2.64		4.75	
FeO	1.23	.60	7.48	2.83
MgO	.22	(?)	18.12	6.48
CaO	1.34	.30	10.55	1.45
Na_2O	10.41	8.32	2.62	2.39
K_2O	4.89	1.22	1.10	.93
H_2O-	.22	(?)	.57	(?)
H_2O+	2.50	(?)	1.25	(?)
TiO_2	.40		2.66	
P_2O_5	.11	.11	.68	.68
ZrO_2	.15		None.	
Cr_2O_3	None.			
NiO	None.		.06	
MnO	.15		.25	
SrO	Trace.		.03	
BaO	.04		.06	
Li_2O	Trace.		Trace.	
S	.01		.01	
SO_3			.03	
Cl	.23		.05	
F	None.		.04	
	99.82	51.79	100.09	53.12
Less O	.05		.03	
	99.77		100.06	

[a] Including Cr_2O_3.

I. Nepheline basalt, Black Mountain, Uvalde quadrangle. *Uvaldose.* Contains olivine, augite, nephelite, magnetite, and apatite. Sp. gr., 3.200, 21.5°. P. R. C. 1066.

J. The portion of I soluble in 1:40 dilute nitric acid.

K. Augite from I. Violet in color, very pure.

L. Nepheline-melilite basalt, from about 3 miles southwest of Uvalde. *Casselose.* Contains nephelite, melilite, olivine, augite, magnetite, and apatite. Sp. gr., 3.150, 20.5°. P. R. C. 1064.

M. The portion of L soluble in 1:40 dilute nitric acid.

	I	J	K	L	M
SiO_2	39.92	12.00	45.23	37.96	19.32
Al_2O_3	8.60	5.15	7.73	10.14	7.12
Fe_2O_3	4.40		2.95	3.69	
FeO	8.00	3.38	4.07	7.59	3.16
MgO	20.17	7.16	12.25	14.69	6.52
CaO	10.68	1.33	23.37	16.28	7.75
Na_2O	1.91	1.77	.47	2.18	2.11
K_2O	1.03	.77	.12	.69	.67
H_2O-	.43	(?)	.37	.39	(?)
H_2O+	1.45	(?)		1.82	(?)
TiO_2	2.70		4.28	2.93	Trace.
P_2O_5	.51	.51	None.	1.13	1.13
ZrO_2	None.			None.	
Cr_2O_3	.14			.08	
V_2O_3	.04			.05	
NiO	.06		.05	.04	
MnO	.24		.07	.22	
SrO	.04		None.	.05	
BaO	.06		None.	.06	
Li_2O	Trace.		Trace.	Trace.	
SO_3				.03	
S	Trace.			.04	
Cl	Trace.			Trace.	
F	.07			.07	
	100.45	32.07	100.96	100.13	47.78
Less O	.03			.03	
	100.42			100.10	

Rocks N to U collected by R. T. Hill in the trans-Pecos region. Descriptions supplied by Whitman Cross. Analyses by W. F. Hillebrand, record No. 1901.

N. Rhyolite, summit of Chisos Mountain, Big Bend of the Rio Grande. *Liparose near alaskose.* Pink porphyry. Rich in alkali feldspars and quartz, with very little riebeckite and barkevikite (?). Sp. gr., 2.602, 15.5°.

O. Rhyolite, near Shafter, Shafter quadrangle. *Liparose near alaskose.* Phenocrysts of sanidine and quartz. Groundmass of alkali feldspars, quartz, riebeckite (?), and ægirite. Spherulitic bands traverse the rock. Sp. gr., 2.617, 15.5°.

P. Rhyolite, north summit of Chisos Mountain. *Liparose.* Consists chiefly of alkali feldspars and quartz, with riebeckite and a little magnetite. Sp. gr., 2.611, 15.5°.

Q. Rhyolite, west of Paisano Mountain, Alpine quadrangle. *Liparose.* Contains alkali feldspars, quartz, arfvedsonite, and ægirite. Sp. gr., 2.635, 15.5°.

	N	O	P	Q
SiO_2	76.30	75.12	74.85	72.86
Al_2O_3	11.53	10.94	12.83	11.74
Fe_2O_3	1.83	2.88	1.40	2.71
FeO	.76	.86	.37	1.66
MgO	.03	.07	.04	.06
CaO	.16	.20	.48	.24
Na_2O	4.01	4.46	4.24	4.63
K_2O	4.70	4.54	5.12	4.92
H_2O-	.19	.18	.24	.51
H_2O+	.34	.19	.30	.40
TiO_2	.16	.20	.15	.20
ZrO_2	.11	.13	.09	.28
CO_2	Trace.	.04	Trace?	Trace.
P_2O_5	None.	None.	Trace.	Trace.
SO_3	....	None.	....	....
S	Trace.	.05	Trace.	Trace.
MnO	Trace.	.08	Trace.	.07
BaO	None.	None.	None.	None.
SrO	None.	None.	None.	None.
Li_2O	Trace.	Trace.	Trace.	Trace.
Rare earths	.02	.04	.07	.05
	100.14	99.98	100.18	100.33

F and Cl not looked for.

R. Grorudite, about 2 miles north of the summit of Chisos Mountain. *Grorudose-pantellerose.* Contains alkali feldspars and subordinate quartz, with riebeckite and ægirite in irregular interstitial patches. Sp. gr., 2.648, 15.5°.

S. Pulaskite, Santiago Mountain. *Nordmarkose.* Consists of alkali feldspars, with subordinate ægirite, ægirite-augite, riebeckite, magnetite, and rare lovenite. Sp. gr., 2.581, 25.5°.

T. Syenite porphyry, Iron Mountain, near Marathon. *Nordmarkose.* Contains many oligoclase-albite phenocrysts in a groundmass of alkali feldspar, with very little quartz. Titanite, apatite, and magnetite are present in small amounts. Sp. gr., 2.577, 15.5°.

U. Essexite, Big Hill Canyon, Rio Grande. *Essexose.* Contains predominant orthoclase, soda-rich plagioclase, and nephelite, with considerable augite, olivine, and magnetite, and small amounts of biotite and apatite. Sp. gr., 2.686, 25.5°.

V. Syenite porphyry, Hueco Tanks, El Paso County. *Phlegrose near nordmarkose.* Collected and described by G. B. Richardson. Contains orthoclase, albite, oligoclase, biotite, augite, quartz, ilmenite, magnetite, and apatite. Analysis by G. Steiger, record No. 2162. P. R. C. 1667.

	R	S	T	U	V
SiO_2	68.25	62.46	65.47	53.34	64.51
Al_2O_3	13.60	17.10	17.93	17.92	16.75
Fe_2O_3	3.66	2.49	2.15	2.27	2.05
FeO	1.43	2.65	.13	5.51	1.00
MgO	.02	.28	.06	1.40	.60
CaO	.54	1.27	1.10	4.19	1.38
Na_2O	6.52	6.84	6.21	6.41	6.08
K_2O	4.73	5.44	5.21	4.32	5.74
H_2O-	.16	.15	.19	.58	.31
H_2O+	.32	.49	.41	2.08	.46
TiO_2	.26	.38	.29	1.60	.75
ZrO_2	.25	.10	.07	Trace.	....
CO_2	Trace.	Trace?	Trace?	Trace?	....
P_2O_5	.02	.11	.19	.44	.11
S	Trace.	None.	Trace.	.03	....
MnO	.04	.18	Trace.	.17	.21
BaO	Trace.	None.	.16	.09	....
SrO	Trace.	None.	Trace.	.06	....
Li_2O	Trace.	Trace.	None.	Trace.	....
Rare earths	.08	.03	.05	.05	....
Cl	....	....	....	....	.04
	99.88	99.97	99.92	100.46	100.02

LAKE SUPERIOR REGION.

1. MARQUETTE REGION, MICHIGAN.

Rocks mostly described by Van Hise and Bayley. When not otherwise specified the descriptions have been published in Mon. XXVIII, and partly in 15th Ann., p. 485.

A. Peridotite, near Opin Lake, SE. ¼ sec. 27, T. 48 N., R. 27 W. *Marquettose.* Contains diallage, olivine, magnetite, and plagioclase. The diallage is partly chloritized, and the olivine is partly serpentinized. Analysis by W. F. Hillebrand, record No. 1452. P. R. C. 996.

B. Altered greenstone, Marquette district. *Camptonose.* Analysis by George Steiger, record No. 1586, hitherto unpublished. P. R. C. 988.

C. Grünerite-magnetite schist, sec. 11, T. 47 N., R. 27 W. Mainly impure grünerite, with magnetite and quartz. Analysis by W. H. Melville, record No. 1403. P. R. C. 984.

D. Like C from sec. 18, T. 47 N., R. 28 W. Analysis by Melville, record No. 1403. P. R. C. 980.

E. Like C and D, from sec. 20, T. 46 N., R. 30 W. Analysis by H. N. Stokes, record No. 1546. C, D, and E are similar schists, and alike in mineralogical composition. P. R. C. 981.

	A	B	C	D	E
SiO_2	39.37	48.85	46.94	49.70	46.25
Al_2O_3	4.47	15.83	.66	1.35	.92
Fe_2O_3	4.96	2.50	4.51	3.10	30.62
FeO	9.13	10.79	33.72	37.19	16.92
MgO	26.53	5.82	6.64	5.72	2.13
CaO	3.70	6.20	3.22	.68	1.69
Na_2O	.50	2.79	.16	Trace.	None.
K_2O	.26	1.31	....	....	None.
H_2O-	.87	.27	.67	1.40	....
H_2O+	7.08	3.77			.42
TiO_2	.66	1.28	None.	....	None.
P_2O_5	.17	.22	.07	.12	.07
Cr_2O_3	.68	....	....	....	....
MnO	.12	.11	.31	.93	1.01
NiO	.21	....	....	....	None.
CuO	....	....	....	....	Trace.
SrO	Trace.	.09	....	....	None.
BaO	Trace.	None.	....	....	None.
CO_2	1.23	None.	2.79	....	None.
SO_3	....	.06	....	....	....
	99.94	99.89	99.69	100.19	100.03

F. Green schist, sec. 34, T. 48 N., R. 27 W., near center of section. Contains plagioclase, chlorite, and quartz. Analysis by George Steiger, record No. 1447. P. R. C. 986.

G. Sericite schist associated with the preceding. Mainly sericite and quartz. Analysis by Steiger, No. 1447. P. R. C. 985.

H. Dark-gray, foliated schist, southeast corner of sec. 30, T. 47 N., R. 30 W. Contains quartz, plagioclase, orthoclase, and biotite. Analysis by Steiger, No. 1525. P. R. C. 991.

I. Schistose gneiss, NW. ¼ sec. 35, T. 47 N., R. 26 W. Contains quartz, kaolin, sericite, plagioclase, chlorite, magnetite, and apatite. Analysis by Steiger, No. 1525.

J. Novaculite from Marquette. Described by Williams in Bull. 62. Contains quartz and sericite. Analysis by W. F. Hillebrand, record No. 759.

	F	G	H	I	J
SiO_2	61.35	70.76	63.50	82.38	76.99
Al_2O_3	16.45	14.83	17.89	11.32	13.92
Fe_2O_3	.94	1.46	1.12	.97	.45
FeO	4.20	3.09	5.38	.26	.77
MgO	3.12	1.99	1.22	.17	1.12
CaO	3.46	.36	2.34	.22	.32
Na_2O	5.24	.47	2.55	.59	.56
K_2O	1.05	3.50	2.43	1.04	3.65
H_2O-	.10	.09	.22	.18	2.35
H_2O+	2.51	2.70	2.04	2.33	
TiO_2	.26	.33	.62	.14	....
P_2O_5	.18	.26	.19	.09	Trace.
MnO	....	....	Trace.	None.	Trace.
Li_2O	....	....	....	....	Trace.
CO_2	1.98	....	....	....	....
	100.84	99.84	99.50	99.69	100.13

2. CRYSTAL FALLS DISTRICT, MICHIGAN.

Rocks described by J. Morgan Clements and H. L. Smyth, in Mon. XXXVI. A, B, C, and D by Smyth, p. 274. Analyses by H. N. Stokes, record No. 1721.

A. Granite, sec. 2, T. 41 N., R. 30 W. *Magdeburgose.* Contains quartz, orthoclase, microcline, plagioclase, biotite, muscovite, magnetite, hematite, titanite, and occasional apatite.

B. Gneiss, sec. 35, T. 42 N., R. 29 W. Same minerals as in A.

C. Mica schist, sec. 35, T. 42 N., R. 29 W. Contains biotite, quartz, some microcline, and magnetite.

D. Amphibolite, sec. 32, T. 42 N., R. 28 W. Contains hornblende, plagioclase, biotite, and quartz, with a little rutile and magnetite.

	A	B	C	D
SiO_2	76.10	74.37	64.71	50.36
Al_2O_3	12.95	13.34	16.43	13.26
Fe_2O_3	.65	.92	1.83	6.30
FeO	.09	.21	3.84	9.34
MgO	.14	.27	2.97	5.55
CaO	.12	.50	.08	7.85
Na_2O	2.36	2.50	.11	2.11
K_2O	6.50	6.70	5.63	1.14
H_2O-	.17	.12	.31	.16
H_2O+	.48	.44	2.79	1.55
TiO_2	.07	.07	.72	1.77
P_2O_5	.02	.01	.02	.20
MnO	Trace.	Trace.	Trace.	Trace.
	99.65	99.45	99.44	99.59

Ba, Sr, Cl, F, S, SO_3 not looked for.

The following rocks, with one exception, are described by Clements in his portion of Mon. XXXVI:

E. Mica diorite, sec. 28, T. 42 N., R. 32 W., southeast of Crystal Falls. *Shoshonose.* Contains plagioclase (andesine), orthoclase, quartz, biotite, hornblende, and titaniferous magnetite. Analysis by Stokes, record No. 1721.

F. Hornblende gabbro, sec. 29, T. 42 N., R. 31 W., west bank Michigamme River, east of Crystal Falls. *Hessose.* Contains labradorite, hornblende, and iron oxide, with subordinate pyroxene, biotite, and orthoclase. Analysis by George Steiger, record No. 1712.

G. Bronzite norite, same locality as F. *Auvergnose.* Contains bronzite, hornblende, and labradorite. Analysis by Steiger, record No. 1712.

H. Wehrlite, sec. 29, T. 42 N., R. 31 W., on Michigamme River, east of Crystal Falls. *Rossweinose.* Contains hornblende, pyroxene, olivine, biotite, and iron oxide. Analysis by Stokes, record No. 1721.

I. Picrite porphyry, sec. 27, T. 44 N., R. 32 W., northwest of Mansfield. Principal minerals serpentine, amphibole, chlorite, ilmenite, all but the last being secondary. Analysis by Stokes, record No. 1721.

	E	F	G	H	I
SiO_2	58.51	49.80	48.23	44.99	37.36
Al_2O_3	16.32	19.96	18.26	5.91	4.76
Fe_2O_3	2.11	6.32	1.26	3.42	6.61
FeO	4.43	.49	6.10	8.30	6.12
MgO	3.73	7.05	10.84	21.02	31.11
CaO	3.92	11.33	9.39	9.79	1.19
Na_2O	3.11	2.22	1.34	.91	Trace.
K_2O	4.08	.61	.73	.74	Trace.
H_2O-	.23	.13	.26	.63	.65
H_2O+	2.00	1.71	2.00	3.19	10.37
TiO_2	.72	.79	1.00	.97	.79
P_2O_5	.30	.07	.07	.05	.06
Cr_2O_3	....	....	....	.25	.62
MnO	Trace.	....	....	Trace.	Trace.
NiO	....	....	....	....	.04
CO_2	None.	.15	.43	Trace?	None.
	99.46	100.63	99.91	99.17	99.68

Ba, Sr, Cl, F, S, SO_3 not looked for.

J. Pre-Cambrian nonporphyritic metabasalt, from the Hemlock formation. *Beerbachose.* Contains plagioclase, light-green hornblende, epidote-zoisite, chlorite, calcite, muscovite, apatite, sphene, quartz, pyrite, and magnetite.

K. Porphyritic metabasalt, Hemlock formation. Same minerals as in J, with feldspar phenocrysts.

L. Porphyritic metabasalt, like K. *SR. 5 of monzonase.*

M. Metadolerite, large dike in T. 43 N., R. 31 W., east of Mansfield. *Auvergnose.* Petrographic data furnished by C. R. Van Hise. Contains uralite, labradorite, and ilmenite.

Analyses J, K, and L by H. N. Stokes, record No. 1617.

Analysis M by George Steiger, record No. 1814.

	J	K	L	M
SiO_2	46.47	47.20	52.59	44.29
Al_2O_3	16.28	15.36	15.89	17.46
Fe_2O_3	3.15	3.06	6.12	3.82
FeO	8.96	8.87	3.96	10.35
MgO	6.56	4.20	5.04	7.03
CaO	7.90	5.05	5.55	8.68
Na_2O	3.64	4.72	5.79	2.19
K_2O	.21	1.40	.67	.71
H_2O-	.28	.16	.16	.21
H_2O+	3.89	3.04	2.16	4.11
TiO_2	1.28	3.30	1.36	1.40
P_2O_5	.13	.36	.15	.20
V_2O_3	....	....	.04	....
Cr_2O_3	.01	None.	Trace.	....
MnO	.09	.20	.25	Trace.
CuO	Trace.	Trace.	Trace.	....
SrO	None.	Trace.	None.	....
BaO	None.	Trace.	Trace.	None.
Li_2O	Trace.	Trace.	None.	....
CO_2	1.26	3.34	None.	....
S	None.	Trace.	None.	....
F	Trace.	Trace.	Trace.	....
	100.11	100.26	99.73	100.45

N. Adinole, sec. 8, T. 43 N., R. 31 W., near Mansfield. Contains actinolite, albite, quartz, some chlorite, and epidote. Analysis by George Steiger, record No. 1709.

O. Spilosite. Contains quartz, feldspar, chlorite, epidote, and a little biotite.

P. Spilosite. Contains quartz, feldspar, actinolite, and epidote.

Analyses O and P by H. N. Stokes, record No. 1617. These three rocks are contact derivatives of the Mansfield clay slate, q. v.

	N	O	P
SiO_2	74.16	52.51	57.77
Al_2O_3	11.85	19.00	19.33
Fe_2O_3	.82	3.31	1.29
FeO	1.66	7.19	3.37
MgO	2.10	3.29	4.35
CaO	2.10	1.55	1.71
Na_2O	6.57	6.72	8.22
K_2O	.15	.70	.22
H_2O-	.05	.34	.18
H_2O+	.52	3.26	2.34
TiO_2	.37	1.70	.92
P_2O_5	.08	.15	.04
MnO	.06	Trace.	Trace.
SrO	None.	Trace.	Trace.
BaO	None.	Trace.	None.
V_2O_3	....	....	.02
Li_2O	....	Trace.	None.
CO_2	.09	None.	None.
C	.18	....	....
F	....	Trace.	None.
	100.76	99.72	99.76

3. KEWEENAW POINT, MICHIGAN.

Analyses made by G. Steiger for A. N. Winchell, who has published them in Jour. Geology, vol. 16, p. 772, but without detailed description of the rocks.

A. Olivine diabase, Greenstone Cliff. *Auvergnose.*

B. "Ashbed" diabase, bed 65, Eagle River section. *Camptonose.*

	A	B
SiO_2	47.69	50.07
Al_2O_3	16.02	12.63
Fe_2O_3	2.41	3.84
FeO	8.70	10.30
MgO	8.31	5.23
CaO	10.54	6.55
Na_2O	2.44	3.53
K_2O	None.	1.90
H_2O-	.44	.86
H_2O+	2.04	1.96
TiO_2	1.38	2.50
P_2O_5	.06	.22
MnO	.26	.42
BaO	None.	.02
	100.29	100.03

ZrO_2, CO_2, S, SO_3, and SrO absent.

4. MENOMINEE RIVER.

STURGEON FALLS GABBRO.

From Sturgeon Falls, Menominee River, sec. 27, T. 39 N., R. 29 W., Michigan. Described by Williams, Bull. 62, p. 67.

A. Saussurite gabbro. *Auvergnose.* Contains plagioclase, almost wholly altered to saussurite, diallage, hornblende, and ilmenite, with quartz, calcite, and chlorite as alteration products. P. R. C. 1755.

B. The same, altered, and somewhat schistose. Feldspar much altered into calcite, with secondary quartz and sericite; pyroxene and hornblende changed to chlorite. Leucoxene common.

C. Light-gray, silvery schist, derived from gabbro. Contains chlorite, calcite, and a little quartz, with remnants of feldspar and some leucoxene. Analyses by R. B. Riggs, record Nos. 389, 390, 391. Material dried at 105°. TiO_2 undetermined.

	A	B	C
SiO_2	51.46	38.05	45.70
Al_2O_3	14.35	24.73	16.53
Fe_2O_3	3.90	5.65	4.63
FeO	5.28	6.08	3.89
MgO	9.54	11.58	9.57
CaO	9.08	1.25	4.28
Na_2O	2.92	2.54	.55
K_2O	.24	1.94	3.82
H_2O	3.30	7.53	4.70
CO_2	.20	.93	5.95
	100.27	100.28	99.62

LOWER QUINNESEC FALLS.

Described by Williams, Bull. 62, pp. 89, 91.

A. Gabbro-diorite, shore below falls, Wisconsin side. *Auvergnose.* Contains saussurite, hornblende, and ilmenite. Some calcite in the saussurite. Hornblende partly altered to chlorite, and ilmenite to leucoxene.

B. The same, schistose form. Contains less saussurite. Hornblende and ilmenite completely altered into chlorite and leucoxene. Calcite present, and also porphyritic feldspar.

C. Silvery schist, adjoining B, and derived from gabbro. Resembles B in general, without the feldspar crystals. Calcite and sericite are present, and rutile in place of leucoxene.

D. Dark massive greenstone. Contains hornblende, chlorite, epidote, quartz, leucoxene, with some ilmenite and traces of original feldspar.

E. Dark schistose greenstone, forming a band in D. Chlorite entirely replaces hornblende, and rutile replaces leucoxene. Some feldspar, quartz, and calcite.

Analyses by R. B. Riggs, record Nos. 384, 385, 386, 387, 388. Material dried at 105°.

	A	B	C	D	E
SiO_2	47.96	49.19	46.21	43.80	44.49
Al_2O_3	16.85	18.71	18.38	16.08	16.37
Fe_2O_3	4.33	5.03	3.30	9.47	5.07
FeO	4.17	4.04	3.90	10.50	5.50
MgO	9.15	7.98	7.03	6.54	7.50
CaO	13.25	5.92	6.28	7.81	7.94
Na_2O	1.25	1.44	2.14	1.96	2.59
K_2O	.30	.77	.35	.34	.56
H_2O	2.89	5.05	3.82	3.99	4.99
CO_2	.08	1.82	8.32	.08	5.38
	100.23	99.95	99.73	100.57	100.39

UPPER QUINNESEC FALLS.

Described by Williams, Bull. 62, pp. 104, 113, 114, 121.

A. Light greenstone. *Auvergnose.* Contains hornblende, feldspar much altered to saussurite, ilmenite with leucoxene border, and some secondary quartz.

B. Mica diorite porphyry. *I. 5. 3. 4.* Mainly andesitic feldspar and biotite, with apatite, zircon, sphene, and some calcite.

C. Biotite gneiss, Michigan side. Contains biotite, soda orthoclase, and quartz. Sphene common, zircon and apatite present.

D. Schistose quartz porphyry. *Toscanose.* Contains quartz, feldspar, sericite, some chlorite, anatase, and tourmaline, with zircon and apatite sparingly. A, B, and D are from the Wisconsin side of the river.

Analyses by R. B. Riggs, record Nos. 392, 393, 394, 395. Material dried at 105°.

	A	B	C	D
SiO_2	48.35	54.83	67.77	66.69
Al_2O_3	15.40	25.49	16.61	16.69
Fe_2O_3	4.04	1.61	2.06	2.06
FeO	4.63	1.65	1.96	.93
MgO	11.61	1.96	1.26	1.15
CaO	10.38	6.08	1.87	1.40
Na_2O	1.87	5.69	4.35	2.46
K_2O	.35	1.87	2.35	5.23
H_2O	3.60	1.18	1.69	1.70
CO_2	.08	.18	.19	1.42
	100.31	100.54	100.11	99.73

SCHIST FROM THE ARAGON IRON MINE.

Described by Bayley in Mon. XLVI, p. 122. Consists of quartz and micaceous minerals, either talc or kaolin and serpentine. Some limonite is present. Analysis by George Steiger, record No. 1835.

SiO_2	49.56	H_2O+	7.66
Al_2O_3	10.12	TiO_2	.60
Fe_2O_3	5.87	P_2O_5	.04
FeO	.13	MnO	Trace.
MgO	20.53	CO_2	None.
CaO	.72		
Alkalies	None.		99.73
H_2O-	4.50		

5. PENOKEE-GOGEBIC REGION.

Rocks mostly described by Van Hise in Mon. XIX. Analyses A to G by T. M. Chatard, record Nos. 991, 992, 993, 994, 995.

A. Diabase, near southeast corner of sec. 13, T. 47 N., R. 46 W., Michigan. *Auvergnose*. Contains plagioclase, augite, magnetite, apatite, and olivine, with some ilmenite and leucoxene. P. R. C. 1001.

B. Same dike as A, partly altered. The pyroxene is altered to amphibole, and the latter partly to biotite. Biotite has also been derived from feldspar. P. R. C. 1000.

C. Feldspar separated from A.

D. Altered diabase, Aurora mine, NE. ¼ SW. ¼ sec. 23, T. 47 N., R. 47 W., Michigan. P. R. C. 1002.

	A	B	C	D
SiO_2	47.90	46.85	51.18	41.60
Al_2O_3	15.60	22.62	27.00	37.20
Fe_2O_3	3.69	5.12	3.19	3.21
FeO	8.41	1.58	Undet.	.30
MgO	8.11	2.01	1.92	.02
CaO	9.99	1.25	11.70	.23
Na_2O	2.05	.80	3.48	.07
K_2O	.23	2.66	.41	....
H_2O-	.15	3.12	1.19	.29
H_2O+	2.34	8.25		13.54
TiO_2	.82	1.12	....	3.79
P_2O_5	.13	.16	....	.14
Cr_2O_3	Trace.	....	....	....
MnO	.17	2.54	.17	.08
NiO	.10	.08	....	....
BaO	.05	.10	....	Trace.
CO_2	.38	1.89	....	.38
	100.12	100.15	100.24	100.85

E. Feldspar separated from gabbro, sec. 14, T. 44 N., R. 4 W., Wisconsin.

F, G. Feldspars separated from olivine diabase, NE. ¼ sec. 13, T. 45 N., R. 1 W., Wisconsin. P. R. C. 1003.

	E	F	G
SiO_2	51.99	61.65	56.15
Al_2O_3	29.32	19.91	26.05
Fe_2O_3	1.23	2.28	1.98
FeO	....	Undet.	Undet.
MgO	.63	.61	.54
CaO	12.60	4.12	8.70
Na_2O	2.91	4.74	4.79
K_2O	.28	5.72	1.56
H_2O-	.03	.95	.13
H_2O+	.54		.64
MnO	Trace.	Trace.	.13
	99.53	99.98	100.67

The following analyses, by W. F. Hillebrand, of separations from the gabbro of Ashland County, Wis., were made for the late R. D. Irving, but were never published by him:

H. Magnetite, record No. 687. Partial analysis.

I. Feldspar, record No. 688.

J. Diallage, record No. 686.

For convenience I also include here, although it is decidedly out of classification—

K. Graywacke, Hurley, Wis. Described by Bayley in Bull. 150, p. 84. Analysis by H. N. Stokes, record No. 1314. Contains quartz, feldspars, iron oxides, and probably kaolin. In the cement are chlorite, quartz, magnetite, pyrite, rutile, occasionally biotite, and either muscovite or kaolin. P. R. C. 20.

	H	I	J	K
SiO_2		53.30	49.80	76.84
Al_2O_3		29.03	2.86	11.76
Fe_2O_3	50.29	.55	2.48	.55
FeO	30.70	.23	10.82	2.88
MgO		.13	15.33	1.39
CaO		11.40	16.50	.70
Na_2O		4.87	.51	2.57
K_2O		.40	.12	1.62
H_2O		.23	.33	1.87
TiO_2	8.77	Trace.	1.29	
P_2O_5		Trace.	Trace.	
MnO		None.	.37	Trace.
SrO		Trace.	None.	
BaO		Trace.	None.	
Li_2O		None.	Trace?	
	89.46	100.14	100.41	100.18

6. PIGEON POINT, MINNESOTA.

Described by Bayley in Bull. 109. Also partly in Am. Jour. Sci., 3d ser., vol. 37, p. 54. A and B are also described in Bull. 150, p. 274.

A. Olivine diabase. *Hessose.* Contains labradorite, olivine, pyroxene, apatite, and magnetite. Analysis by W. F. Hillebrand, record No. 496. P. R. C. 107.

B. Diallage separated from diabase. Partial analysis by R. B. Riggs, record No. 607.

C. Rock lying between the diabase and the adjacent red porphyry. *Adamellose.* Contains red feldspar, quartz, hornblende, chlorite, magnetite, apatite, and rutile. Analysis by W. F. Hillebrand, record No. 500. P. R. C. 1018.

	A	B	C
SiO_2	49.88	48.34	57.98
Al_2O_3	18.55	2.90	13.58
Fe_2O_3	2.06	4.68	3.11
FeO	8.37	14.15	8.68
MgO	5.77	11.34	2.87
CaO	9.72	15.10	2.01
Na_2O	2.59		3.56
K_2O	.68		3.44
H_2O	1.04		2.47
TiO_2	1.19	1.98	1.75
P_2O_5	.16		.29
ZrO_2	None.		
MnO	.09		.13
SrO	Trace.		Trace.
BaO	.02		.04
Li_2O	None.		Trace.
Cl	Trace.		Trace.
	100.12	98.49	99.91

D. Red soda granite. *Liparose.* Contains feldspar, quartz, chlorite, some muscovite, rutile, leucoxene, hematite, and apatite, with sometimes secondary calcite. Granular variety. Analysis by W. F. Hillebrand, record No. 495. Dried at 110°.

E. Same as D, porphyritic variety. *Toscanose.* Called by Bayley a quartz keratophyre. Analysis by Hillebrand, record No. 497.

F. Similar red porphyry, Little Brick Island, Lake Superior, near Pigeon Point. *Liparose.* Consists chiefly of feldspar and quartz, with augite occasionally present. Analysis by L. G. Eakins, record No. 1059.

G. Red feldspar, anorthoclase, separated from D. Contains hematite inclusions. Analysis by J. E. Whitfield, record No. 521. Dried at 104°.

	D	E	F	G
SiO_2	72.42	74.00	73.70	65.00
Al_2O_3	13.04	12.04	12.87	18.22
Fe_2O_3	.68	.78	3.76	2.64
FeO	2.49	2.61	.31	....
MgO	.58	.42	.11	.06
CaO	.66	.85	.14	1.06
Na_2O	3.44	3.47	3.63	8.40
K_2O	4.97	4.33	4.56	4.18
H_2O	1.21	.86	.57	.46
TiO_2	.40	.34	.12	....
P_2O_5	.20	.06	Trace.	....
MnO	.09	.05	.07	....
SrO	Trace?	Trace.	....	....
BaO	.15	.12	....	....
Li_2O	Trace?	Trace?	....	....
Cl	Trace.	Trace.	....	....
	100.33	99.93	99.84	100.02

H. Dark vitreous quartzite. Contains quartz, a little red feldspar, some chlorite, some green mica, a few scales of biotite, and grains of magnetite. P. R. C. 1007.

I. Lighter interbedded quartzite. Feldspar in it much altered. P. R. C. 1004.

J. Epidotic quartzite. P. R. C. 1023.

K. Unaltered quartzite. P. R. C. 1006.

Analyses by R. B. Riggs, record Nos. 569, 571, 572, 575. Material dried at 105°.

	H	I	J	K
SiO_2	74.22	73.65	73.14	73.64
Al_2O_3	10.61	11.08	12.60	11.25
Fe_2O_3	7.45	7.24	7.57	6.24
FeO	.85	.77	1.31	1.04
MgO	1.48	1.52	1.67	1.57
CaO	.56	.40	.43	.36
Na_2O	2.12	1.67	1.78	3.04
K_2O	1.08	1.65	1.00	1.42
Ign	1.79	1.88	.83	1.98
TiO_2	.16	Trace.	.04	Trace.
MnO	None.	Trace.	Trace.	None.
	100.32	99.86	100.37	100.54

Ba and Sr not looked for.

L. Altered quartzite. Contains more fibrous chlorite, some sericite, a little kaolin and biotite, grains of magnetite, earthy matter, and sometimes a little calcite. Analysis by R. B. Riggs, record No. 570. P. R. C. 1009.

M. Mottled quartzite. Analysis by Riggs, record No. 573. P. R. C. 1021.

N. Purplish slate, containing many small crystals of red feldspar and scales of mica. Analyses by J. E. Whitfield, record No. 520. P. R. C. 1024.

O. Very slightly altered slate. Analysis by Riggs, record No. 576. P. R. C. 1011. Material for analysis dried at 104°-105°.

	L	M	N	O
SiO_2	71.00	72.25	63.82	59.71
Al_2O_3	12.88	10.73	14.65	18.32
Fe_2O_3	6.69	8.01	3.16	8.11
FeO	.65	.38	5.12	.85
MgO	1.68	1.85	2.08	3.54
CaO	.21	.42	.70	1.05
Na_2O	1.43	2.03	1.95	1.93
K_2O	2.95	2.56	2.81	3.43
H_2O	2.03	2.05	2.62	3.24
TiO_2	.44	Trace.	2.66	Trace.
P_2O_5	....	....	.19	....
MnO	Trace.	Trace.	None.	None.
Li_2O	....	....	None.	....
SO_3	....	....	.33	....
	99.96	100.28	100.09	100.18

Ba and Sr not looked for.

P. Red granitic rock resembling D, but with more dark spots, found in contact with the purplish slate, N. *Liparose.* Consists mainly of red feldspar, quartz, and chlorite. Analysis by J. E. Whitfield, record No. 519. Dried at 104°, P. R. C. 1014.

Q. Groundmass of red mottled quartzite. Analysis by W. F. Hillebrand, record No. 499. P. R. C. 1022.

R. Green mottlings from Q. Mostly quartz and sericite. Analysis by Hillebrand, record No. 498.

S. Another sample of the green mottlings, selected with especial care. Analysis by L. G. Eakins, record No. 1058.

T. Brilliantly red vitreous quartzite. Analysis by R. B. Riggs, record No. 574. Dried at 105°. P. R. C. 1008.

	P	Q	R	S	T
SiO_2	68.36	76.57	77.70	83.27	83.69
Al_2O_3	13.76	9.21	7.67	7.81	7.50
Fe_2O_3	2.65	1.67	3.55	1.99	1.81
FeO	2.75	3.94	3.29	1.81	.38
MgO	.68	1.51	1.83	1.59	.35
CaO	.70	.73	.26	.20	.39
Na_2O	3.56	3.07	1.96	.19	2.46
K_2O	4.48	1.02	1.04	1.11	2.61
H_2O	.98	1.89	[a]2.36	2.32	.72
TiO_2	1.57	.42	.30	Trace.	Trace?
P_2O_5	.33	Trace.	None.	Trace.	....
ZrO_2	....	None.	....	....	....
MnO	Trace.	.05	.04	....	Trace.
SrO	Undet.	Trace?	(?)	....	Undet.
BaO	Undet.	None.	None.	....	Undet.
Li_2O	None.	Trace.	Trace.	....	....
SO_3	.66	....	....	....	....
	100.48	100.08	100.00	100.29	99.91

[a] Determined by difference.

7. MESABI DISTRICT, MINNESOTA.

The following rocks, described by Leith in Mon. XLIII, do not fall legitimately within this section of the present bulletin. There seems, however, to be no other convenient place for them, and so the niceties of classification have been ignored for reasons of expediency.

A. Greenalite rock, test pit, Cincinnati mine. Contains green and brown transparent granules, with opaque brown to black ones, in a matrix of chert. P. R. C. 1668.

B. Greenalite rock, same locality as A. Contains greenish-yellow granules, slightly altered to amphibole in a matrix of amphibole with subordinate chert. P. R. C. 1669.

C. Greenalite rock, near W. quarter post, sec. 35, T. 59 N., R. 15 W. Resembles A. P. R. C. 1670.

D. Greenalite rock, near SE. corner of sec. 22, T. 59 N., R. 15 W. Contains yellowish-brown, transparent, and dark-brown to black and opaque granules in a matrix which is mainly amphibole, possibly actinolite. All four rocks contain oxides of iron, either limonite or magnetite. P. R. C. 1671.

Analyses by George Steiger, record Nos. 1931 and 1992. In three of the rocks the portions soluble and insoluble in hydrochloric acid were analyzed separately.

	A		B		C		D
	Insoluble.	Soluble.	Insoluble.	Soluble.	Insoluble.	Soluble.	
SiO_2	36.50	19.30	13.01	33.11	48.45	13.45	50.96
Al_2O_3	.76	.61	2.60	.56	.64	.37	1.09
Fe_2O_3		13.83		6.44		15.00	5.91
FeO		17.57		30.93		10.28	30.37
MgO	....	3.22	....	5.35	....	2.33	5.26
CaO	....	None.	....	None.	....	.28	.04
Alkalies	....	None.	....	None.	....	None.	None.
H_2O-	....	2.38	....	1.34	....	2.50	.75
H_2O+	....	5.74	....	6.13	....	4.17	6.41
TiO_2	....	None.	....	None.	....	None.	None.
CO_2	....	None.	....	None.	....	2.04	None.
P_2O_5	....	None.	....	None.	....	None.	None.
C (organic)	....	....	....	....	....	....	.21
	37.26	62.65	15.61	83.86	49.09	50.42	100.10
Insoluble	....	37.26	....	15.61	....	49.09	....
	....	99.91	....	99.47	....	99.51	....

E. Ferruginous chert, sec. 28, T. 58 N., R. 17 W. P. R. C. 1672.

F. Ferruginous chert, horizon of ore deposits, Oliver mine. P. R. C. 1673.

G. Amphibolitic chert, Old Chicago mine. P. R. C. 1674.

H. Amphibolitic chert, one-half mile southwest of Virginia. P. R. C. 1675.

I. Amphibolitic chert, Donora mine. P. R. C. 1676.

G, H, and I are largely amphibole in a matrix of chert. Analyses by George Steiger, record Nos. 1931, 1948.

	E	F	G	H	I
SiO_2	63.92	32.56	50.36	83.82	44.10
Al_2O_3	None.	None.	.64	.39	1.05
Fe_2O_3	31.13	66.02	6.46	4.46	10.80
FeO	3.13	.30	32.91	8.77	28.73
MgO	.49	None.	3.94	None.	2.43
CaO	None.	.18	.23	.60	.33
Alkalies	Trace.	None.	None.	None.	None.
H_2O-	.48	.32	.27	.13	.51
H_2O+	1.12	.90	4.64	1.37	2.47
TiO_2	Trace.	.16	None.	None.	None.
CO_2	None.	None.	None.	.72	9.71
P_2O_5	.05	.12	None.	.02	.04
MnO	.10	.14	None.	None.	None.
C (organic)	....	....	.18	....	....
	100.42	100.70	99.63	100.28	100.17

8. MISCELLANEOUS ROCKS FROM MINNESOTA.

A. Granulitic hypersthene gabbro, from SE. ¼ sec. 20, T. 65 N., R. 4 W. *Cookose.* Described by Bayley, Jour. Geology, vol. 3, p. 1. Contains hypersthene, biotite, diallage, magnetite, and plagioclase. Analysis by H. N. Stokes, record No. 1267.

B. Hypersthene from A. Analysis by E. A. Schneider, record No. 1358.

C. Granulitic diallage gabbro, SE. ¼ NW. ¼ sec. 26, T. 64 N., R. 8 W. *Auvergnose.* Described by Bayley, Jour. Geology, vol. 3, p. 1. Contains diallage, hypersthene, magnetite, and plagioclase. Analysis by W. H. Melville, record No. 1403.

D. Olivine gabbro, west side of Birch Lake, SE. ¼ sec. 19, T. 63 N., R. 4 W. *Auvergnose.* Described by Bayley, Jour. Geology, vol. 1, p. 688. Contains a large proportion of diallage and olivine. Analysis by Stokes, No. 1267.

E. Olivine from D. Analysis by W. F. Hillebrand, record No. 1308.

	A	B	C	D	E
SiO_2	46.96	48.44	49.56	45.66	35.58
Al_2O_3	14.13	7.91	17.81	16.44	.92
Fe_2O_3	.76	.33	2.76	.66	33.91
FeO	14.95	20.88	9.48	13.90	
MgO	15.97	19.35	5.93	11.57	26.86
CaO	2.32	1.44	9.70	7.23	.90
Na_2O	.35	....	2.87	2.13	....
K_2O	1.68	....	....	.41	....
H_2O-	.07	.08	.50	07	.11
H_2O+	1.26	None.		.83	.20
TiO_2	.62	Undet.	.48	.92	1.22
P_2O_5	.03	....	.67	.05	....
Cr_2O_3	Trace.	....	....	Trace.	Trace.
MnO	.93	.92	.06	Trace.	.35
CoO	....	....	....	....	.20
NiO	.06	....	....	.16	
CO_2	....	....	Trace.	....	....
	100.09	99.35	99.82	100.03	100.25

F. Average gabbro, south quarter post, sec. 35, T. 61 N., R. 12 W. *Hessose.* Described by Bayley in Jour. Geology, vol. 1, p. 688. Contains plagioclase, olivine, pyroxene, and magnetite. Analysis by H. N. Stokes, record No. 1267.

G. Feldspar, from preceding gabbro. Analysis by W. F. Hillebrand, record No. 1308.

H. Feldspar, from gabbro east side of North Fowl Lake. Analysis by Hillebrand, No. 1308.

I. Feldspar, from gabbro, NW. ¼ SE. ¼ sec. 23, T. 62 N., R. 10 W.

J. Feldspar, from gabbro, center of sec. 25, T. 64 N., R. 8 W.

K. Feldspar, from gabbro, Duluth and Iron Range Railroad.

Analyses I, J, and K by Hillebrand, record No. 1115. H, I, J, and K analyzed for W. S. Bayley.

	F	G	H	I	J	K
SiO_2	46.45	51.89	62.71	52.50	52.61	53.45
Al_2O_3	21.30	29.68	19.20	30.15	29.80	29.77
Fe_2O_3	.81	.32	1.08	.47	.57	.33
FeO	9.57	.37	.93	.15	.23	.15
MgO	7.90	.38	.81	.10	.20	.11
CaO	9.83	12.62	.44	12.82	12.25	11.33
Na_2O	2.14	3.87	2.96	3.72	3.80	4.33
K_2O	.34	.50	10.41	.53	.53	.68
H_2O-	.14	.07	.23	.25	.29	.23
H_2O+	1.02	.39	.92			
TiO_2	1.19	....	Trace.	Trace.	Trace.	Trace.
P_2O_5	.02	....	....	....	....	....
[illegible]O	.04	....	....	....	....	....
[illegible]O	Trace.	....	Trace.	....	Trace.	....
[illegible]O	....	....	Trace.	....	....	....
	100.75	100.09	99.69	100.69	100.28	100.38

L. Garnetiferous gabbro, Granite Falls. *Bandose.* Described by W. S. Bayley in Bull. 150, p. 282. Contains plagioclase, augite, garnet, magnetite, a little hornblende, some quartz grains, and apatite. Analysis by H. N. Stokes, record No. 1296. Sp. gr., 3.105. P. R. C. 109.

M. Gabbro-diorite, Minnesota Falls. *Hessose.* Described by Bayley in Bull. 150, p. 369. Essentially plagioclase and hornblende, with some kaolin, augite, and biotite. Analysis by Stokes, No. 1296. Sp. gr., 2.935. P. R. C. 144.

N. Quartz norite gneiss, Odessa. Described by Bayley in Bull. 150, p. 358. Contains quartz, plagioclase, pyroxene, biotite, garnet, magnetite, and sulphide of iron. Analysis by Stokes, No. 1296. Sp. gr., 2.770. P. R. C. 140.

O. Mica schist, bed of Cross River, near Gunflint Lake. Description furnished by C. R. Van Hise. Contains biotite, quartz, feldspar (?), and pyrites. Analysis by T. M. Chatard, record No. 896.

P. Actinolite-magnetite schist, SE. ¼ SE. ¼ sec. 34, T. 61 N., R. 12 W. Described by Bayley in Am. Jour. Sci., 3d ser., vol. 46, p. 178. Mainly actinolite and magnetite. Analysis by W. H. Melville, record No. 1403.

Q. Magnetite rock near the preceding, also described with P by Bayley. Analysis by Melville, No. 1403.

	L	M	N	O	P	Q
SiO_2	52.31	48.29	61.04	64.77	12.35	1.16
Al_2O_3	18.35	20.87	16.97	14.45	.10	1.81
Fe_2O_3	5.90	1.13	....	1.84	58.68	69.08
FeO	11.06	4.98	5.58	4.54	21.34	27.10
MgO	1.00	7.54	3.62	2.34	4.08	.25
CaO	7.33	14.32	5.99	2.33	1.91	.53
Na_2O	2.90	1.77	1.96	1.37	Trace.	....
K_2O	.49	.38	.55	5.03	....	....
H_2O-	.35	.80	.43	.07	.19	....
H_2O+				1.92		
TiO_2	....	....	....	.60	.12	None.
P_2O_5	....	....	....	.20	.25	.06
MnO	....	....	....	.11	1.22	.33
SO_3	....	....	....	.60	....	....
CO_2	....	....	....	.41	....	....
FeS	....	....	[a] 3.73	....	....	....
	99.69	100.12	99.87	100.58	100.24	100.32

[a] Probably pyrrhotite.

SOUTH DAKOTA.

A. Phonolite, Black Hills. *Miaskose.* Described by Whitman Cross in Bull. 150, p. 191. Contains sanidine, nephelite, ægirite, nosean, and sodalite, with accessory sphene, apatite, and zircon, and possibly some rare zirconates or titanates. Also, sparingly, secondary zeolites and calcite. No magnetite, but minute ferritic flakes are disseminated through the rock. Analysis by W. F. Hillebrand, record No. 1618. P. R. C. 73.

B. An earlier analysis of A, by H. N. Stokes, record No. 1314. This was made along the ordinary lines as regards "completeness," as requested by the collector, and without regard to minor accessory constituents. It serves well to illustrate the difference between the two modes of treatment, in comparison with the fuller analysis.

C. Tourmaline-biotite schist, north of Harney Peak, Black Hills. Described by Bayley in Bull. 150, p. 327. Contains quartz, biotite, tourmaline, a little garnet and rarely muscovite, iron ore, and apatite. Analysis by Stokes, record No. 1296. P. R. C. 130.

D. Volcanic ash, 3 miles west of Argyle, Custer County. *Amiatose.* Collected by N. H. Darton. Analysis by George Steiger, record No. 1875. P. R. C. 599.

	A	B	C	D
SiO_2	57.86	58.60	66.77	64.47
Al_2O_3	20.26	20.98	17.65	14.74
Fe_2O_3	2.35	2.22	1.55	2.73
FeO	.39	.44	3.29	.78
MgO	.04	.33	2.13	.29
CaO	.89	1.13	.56	4.00
Na_2O	9.47	8.38	.99	2.55
K_2O	5.19	5.49	4.49	3.31
H_2O-	.21	1.92	1.89	.93
H_2O+	2.40			4.78
TiO_2	.22	....	....	.76
P_2O_5	.03	....	....	.29
ZrO_2	.15	....	....	....
MnO	.21	.20	....	....
SrO	.04	....	....	....
BaO	.09	....	....	.13
Li_2O	Trace.	....	....	....
SO_3	.06	....	....	....
S	.03	....	....	....
Cl	.08	....	....	....
F	(?)	....	....	....
CO_2	None.	....	....	....
	99.97	99.69	99.32	99.76

WYOMING.

Rocks A to J, inclusive, studied by Whitman Cross. The Leucite Hills series is described in Am. Jour. Sci., 4th ser., vol. 4, p. 115. Analysis H is by Chase Palmer, record No. 2473, and K by L. G. Eakins, No. 1078. The others are by W. F. Hillebrand, one made in the Denver laboratory, and record Nos. 343, 355, 362, 368, 403, 463, 1668, and 1682.

A. Wyomingite, Boars Tusk, Leucite Hills. *Wyomingose.* Contains phlogopite, leucite, diopside, and apatite. Sp. gr., 2.779, 13.5°. P. R. C. 566.

B. Wyomingite. Fifteenmile Spring, Leucite Hills, *Orendose.* Composition like A. Sp. gr., 2.627, 30°. P. R. C. 567.

C. Portion of B soluble in 2.5 per cent nitric acid.

D. Phlogopite from wyomingite.

E. Madupite, Pilot Butte, Leucite Hills. *Madupose.* Contains predominating diopside and phlogopite, with perofskite and magnetite, in a glassy base which has approximately the composition of leucite. Sp. gr., 2.857, 22°. P. R. C. 576.

	A	B	C	D	E
SiO_2	50.23	53.70	6.08	42.56	42.65
Al_2O_3	11.22	11.16	.91	12.18	9.14
Fe_2O_3	3.34	3.10	.50	2.73	5.13
FeO	1.84	1.21		.90	1.07
MgO	7.09	6.44	1.51	22.40	10.89
CaO	5.99	3.46	2.13	.20	12.36
Na_2O	1.37	1.67	.28	.44	.90
K_2O	9.81	11.16	1.21	10.70	7.99
H_2O-	.93	.80	(?)	....	2.04
H_2O+	1.72	2.61	(?)	2.35	2.18
TiO_2	2.27	1.92	.21	2.09	1.64
P_2O_5	1.89	1.75	1.54	.06	1.52
Cr_2O_3	.10	.04	....	.73	.07
Di_2O_3, etc.[a]	.03	None.	....	....	.11
MnO	.05	.04	....	....	.12
SrO	.24	.19	.10	Trace.	.33
BaO	1.23	.62	.14	1.00	.89
Li_2O	Trace.	Trace.	....	Trace.	Trace.
SO_3	.74	.06	.06	....	.58
Cl	.03	.03	.03	....	.03
F	.50	.44	....	2.46	.47
	100.62	100.40	14.70	100.80	100.11
Less O	.22	.19	....	1.03	.20
	100.40	100.21	....	99.77	99.91

[a] Probably contains other rare earths.

F. Orendite, Fifteenmile Spring, Leucite Hills. *Orendose.* Contains predominating leucite and sanidine, with phlogopite, a little biotite, diopside, and amphibole, and accessory apatite and rutile. Sp. gr., 2.686, 23.5°. P. R. C. 72 and 572.

G. Orendite, North Table Butte, Leucite Hills. *Orendose.* Composition like F. Sp. gr., 2.699, 19°. P. R. C. 570.

H. Orendite, Hallock Butte, Leucite Hills. *Orendose.* Published by Cross in Bull. 512.

I. Groundmass of F. Sp. gr., 2.615, 19°. Not cited in published paper.

J. Diopside separated from mixed wyomingite and madupite. Sp. gr., 3.290, 20°. Analyzed in the Denver laboratory. P_2O_5 included with TiO_2.

K. Dacite (?), Garfield Peak. Phenocrysts of plagioclase and hornblende, with microscopic sphene and apatite in a groundmass containing plagioclase, orthoclase, quartz, and magnetite. Sp. gr., 2.576, 26.2°. P. R. C. 159.

	F	G	H	I	J	K
SiO_2	54.08	54.17	51.07	58.13	50.86	67.78
Al_2O_3	9.47	10.16	9.93	11.72		16.67
Fe_2O_3	3.19	3.34	2.72	3.01	1.19	1.99
FeO	1.03	.65	1.19	1.01	1.82	.51
MgO	6.74	6.62	10.31	5.79	17.42	.71
CaO	3.55	4.19	4.87	2.24	23.32	2.67
Na_2O	1.39	1.21	.82	1.36	.76	4.91
K_2O	11.76	11.91	9.92	12.58	.42	3.43
H_2O-	.79	.52	2.04	.99		1.44
H_2O+	2.71	1.01	2.19	1.16	.31	
TiO_2	2.08	2.67	2.13	1.48	3.03	.19
P_2O_5	1.36	1.59	1.53	.32		
ZrO_2	Undet.	.22		Undet.		
V_2O_3	.02					
Cr_2O_3	.07	.05				
NiO		Trace.				
MnO	.05	.06	.04	Trace.	.03	Trace.
SrO	.20	.18		.10		
BaO	.67	.59	.57	.29		
Li_2O	Trace.	Trace.		Trace.		
SO_3	.29	.16	.83	.13		
CO_2		.49	None.			
Cl	.04	.06		Trace.		
F	.49	.36		Trace.		
	99.98	100.21	99.66	100.31	99.16	100.30
Less O	.21	.17				
	99.77	100.04				

The four following rocks from Encampment quadrangle are described by A. C. Spencer in P. P. 25. Analyses by E. T. Allen, record No. 2048.

K. Norite, near head of Cow Creek, about three-fourths of a mile from Bridger Peak. *Auvergnose.* Contains chiefly hypersthene and labradorite, the latter slightly altered to sericite. Biotite and magnetite are present, with a few grains of diallage and a little hornblende.

L. Diorite derived from norite, altered form of K. The pyroxene is completely changed to uralite and the feldspar is largely decomposed.

M. Diorite derived from norite, 2 miles west of the Verdi mine. Contains uralite and labradorite, with a little biotite and magnetite.

N. Diorite, probably derived from gabbro, near head of Big Sandstone Creek. Contains much zoisite derived from the feldspars.

	K	L	M	N
SiO_2	52.00	50.03	46.39	50.20
Al_2O_3	11.59	10.89	16.17	15.54
Fe_2O_3	2.72	2.32	2.65	2.14
FeO	7.18	7.99	9.30	6.49
MgO	12.87	11.84	8.58	7.33
CaO	10.49	9.73	8.90	11.96
Na_2O	1.06	1.66	2.25	2.03
K_2O	.92	.57	.73	.40
H_2O-	.18	.46	.47	.43
H_2O+	.37	2.61	2.59	2.52
TiO_2	.99	1.23	1.59	1.00
CO_2	None.	.78	None.	None.
P_2O_5	Trace.	.02	.06	.09
S	Trace.	Trace.	.01	.03
Cr_2O_3	Trace.	Trace.	Trace.	Trace.
MnO	Trace.	Trace.	Trace.	Trace.
BaO	Trace.	.04	.02	None.
NiO, CoO	.04	None.	Trace.	....
CuO	....	....	.02	....
	100.41	100.17	99.73	100.16

The following rocks, from Sundance quadrangle, are described by W. S. T. Smith in Folio 127. Analyses by George Steiger, record No. 1999.

O. Trachytoid phonolite. *Pulaskose*. Contains phenocrysts of orthoclase, ægirine-augite, a little augite, nepheline (?), magnetite, garnet, titanite, and apatite. Groundmass mainly feldspar, probably orthoclase, and other minerals as above, with possibly some species of the sodalite group. P. R. C. 1756.

P. Phonolite. *Essexose*. Contains phenocrysts of feldspar, apparently orthoclase and anorthoclase, ægirine-augite or little augite, garnet, probably nosean, titanite, magnetite, and apatite. In the groundmass, feldspar (orthoclase ?), ægirine-augite, and possibly sodalite. P. R. C. 1757.

Q. Trachytoid phonolite. *Akerose-laurvikose*. Contains phenocrysts of feldspar (orthoclase and plagioclase ?), ægirine-augite, magnetite, titanite, and apatite. In the groundmass, feldspar, magnetite, ægirine-augite, and apatite. P. R. C. 1758.

R. Augite vogesite. *Kentallenose*. Contains phenocrysts of augite, magnetite, apatite, biotite, orthoclase, and plagioclase. Same minerals in the groundmass, with perhaps some species of the nepheline-sodalite group.

	O	P	Q	R
SiO_2	55.14	57.46	58.08	42.95
Al_2O_3	18.98	18.41	18.38	12.44
Fe_2O_3	2.00	2.40	3.02	10.16
FeO	1.62	1.28	1.42	5.18
MgO	.32	None.	.96	5.82
CaO	3.96	4.02	3.85	13.11
Na_2O	5.38	9.23	6.22	2.10
K_2O	6.64	4.93	5.11	2.29
H_2O-	.63	.45	.37	.91
H_2O+	3.70	1.12	1.55	1.98
TiO_2	.50	.42	.58	1.34
P_2O_5	.17	.11	.21	1.37
SO_3	.10	.50	.07	.15
Cl	Trace.	.23	Trace.	.07
S	.08	.05	None.	None.
MnO	Trace.	.11	.10	.29
BaO	....	None.	None.	None.
	99.77	100.72	99.92	100.16
Less O	.01	.08	....	.02
	99.76	100.64	....	100.14

No CO_2 in any of these rocks.

YELLOWSTONE NATIONAL PARK AND THE ABSAROKA RANGE.

1. ELECTRIC PEAK.

Rocks described by Iddings in 12th Ann., p. 577. Also in Bull. Philos. Soc. Washington, vol. 11, p. 206. For analyses O, P, see Mon. XXXII, pt. 2.

A. Pyroxene-mica diorite. *Tonalose.* Contains augite, hypersthene, plagioclase, quartz, biotite, hornblende, magnetite, and apatite. Analysis by J. E. Whitfield, record No. 830. P. R. C. 94.

B. Pyroxene-mica diorite. *Andose.* Same minerals as under A. Analysis by Whitfield, No. 921.

C. Pyroxene-mica diorite. *Tonalose.* Like A and B. Analysis by W. H. Melville, record No. 1231.

D. Pyroxene porphyry. *Andose.* Contains augite, hypersthene, biotite, magnetite, plagioclase, and quartz. Analysis by Whitfield, No. 830.

E. Quartz-pyroxene-mica diorite. *Tonalose.* Contains biotite, hornblende, augite, hypersthene, magnetite, plagioclase, orthoclase, and quartz. Analysis by Melville, No. 1231.

	A	B	C	D	E
SiO_2	56.28	58.05	61.22	57.38	64.07
Al_2O_3	14.23	18.00	16.14	16.86	15.82
Fe_2O_3	4.69	2.49	3.01	2.49	3.40
FeO	4.05	4.56	2.58	5.17	1.44
MgO	6.37	3.55	4.21	5.51	3.39
CaO	7.94	6.17	5.46	7.32	4.43
Na_2O	2.98	3.64	4.48	3.33	4.06
K_2O	1.23	2.18	1.87	1.45	2.27
H_2O-	.93	.86	.04	.42	.10
H_2O+			.40		.42
TiO_2	.84	1.05	.61	Trace.	.45
P_2O_5	.40	.17	.25	Trace.	.18
MnO	.16	None.	Trace.	Trace.	Trace.
NiO	....	....	.09	....	.05
Li_2O	.01	None.	....	.39	....
SO_3	Trace.	.07	....	.21	....
Cl	.17	Trace.	....	.17	....
	100.28	100.79	100.36	100.70	100.08

F. Quartz-mica diorite. *Tonalose.* Contains biotite, hornblende, augite, hypersthene, plagioclase, orthoclase, and quartz. Analysis by Whitfield, No. 921.

G. Quartz-mica diorite. *Yellowstonose.* Contains biotite, hornblende, plagioclase, pyroxene, quartz, and orthoclase. Analysis by Whitfield, No. 921.

H, I, J. Quartz-mica diorites. *Yellowstonose.* Contains hornblende, biotite, plagioclase, orthoclase, and quartz. Analyses by Whitfield, Nos. 921 and 830.

	F	G	H	I	J
SiO_2	65.11	65.60	64.85	66.05	67.54
Al_2O_3	16.21	17.61	16.57	16.96	17.02
Fe_2O_3	1.06	.95	2.10	2.59	2.97
FeO	3.19	2.76	2.15	1.38	.34
MgO	2.57	1.49	2.14	2.08	.13
CaO	3.97	3.72	4.01	3.37	3.36
Na_2O	4.00	4.36	3.71	4.20	4.62
K_2O	2.51	2.36	3.10	2.53	2.28
H_2O	.94	.59	.35	.69	.55
TiO_2	.71	.75	.91	.34	.80
P_2O_5	.02	.16	.14	Trace.	Trace.
MnO	None.	None.	None.	None.	Trace.
Li_2O	.04	.03	None.	None.	.03
SO_3	Trace.	Trace.	Trace.	.03	.26
Cl	None.	None.	None.	Trace.	.15
	100.33	100.38	100.03	100.22	100.05

K. Quartz-mica diorite porphyry. *Yellowstonose.* Contains biotite, hornblende, plagioclase, orthoclase, and quartz. Analysis by Whitfield, No. 830.

L. Quartz-mica diorite porphyry. *Lassenose.* Contains quartz, biotite, plagioclase, alkali feldspar, and hornblende. Analysis by Whitfield, No. 830.

M. Hornblende porphyry. *Tonalose.* Intrusive sheet. Contains hornblende, plagioclase, magnetite, and quartz. Analysis by Whitfield, No. 429.

N. Hornblende-mica porphyry. *Yellowstonose.* Intrusive sheet. Contains hornblende, plagioclase, biotite, magnetite, and quartz. Analysis by Whitfield, No. 420. The Indian Creek laccolith.

O. Augite andesite porphyry. *Monzonose.* Intrusive sheet, upper portion. Contains malacolite, plagioclase, probably orthoclase, magnetite, and little biotite, with secondary chlorite or serpentine and actinolite. Analysis by Whitfield, No. 830.

P. Same sheet as O, lower portion. *Kentallenose.* Analysis by W. F. Hillebrand, record No. 1571.

	K	L	M	N	O	P
SiO_2	65.97	69.24	58.49	61.50	52.10	50.59
Al_2O_3	16.53	15.30	16.70	17.42	16.34	11.49
Fe_2O_3	2.59	1.72	3.85	4.66	3.84	1.83
FeO	1.72	.69	2.37	1.09	6.82	7.64
MgO	2.11	.95	3.12	1.26	4.33	11.27
CaO	3.37	2.98	5.90	5.33	4.73	8.79
Na_2O	3.41	4.46	3.47	3.99	4.02	2.27
K_2O	2.67	2.52	1.59	1.29	4.20	2.33
H_2O-	1.23	1.30	2.44	2.44	1.74	.21
H_2O+						1.76
TiO_2	.42	.65	1.71	None.	.79	.80
P_2O_5	Trace.	Trace.	Trace.	.60	.68	.48
MnO	None.	Trace.	.24	Trace.	Trace.	.17
NiO	....	....	....	....	....	.06
SrO	....	....	....	....	....	.03
BaO	....	....	....	....	....	.10
Li_2O	.09	None.	.01	.03	.13	Trace.
V_2O_3	....	....	....	....	....	.04
SO_3	.13	.27	.63	.35	.22	None.
Cl	.09	Trace.	....	....	.24	Trace.
	100.33	100.08	100.52	99.96	100.18	99.86
$O=Cl$	.02	....	....	....	.05	....
	100.31	....	....	....	100.13	....

2. SEPULCHRE MOUNTAIN.

Rocks described by Iddings, 12th Ann., p. 633. Also in Bull. Philos. Soc. Washington, vol. 11, p. 210, and in Mon. XXXII, pt. 2.

A. Pyroxene andesite. *Tonalose.* Essentially composed of augite, hypersthene, and plagioclase. Analysis by J. E. Whitfield, record No. 923.

B. Pyroxene andesite. *Andose.* Composition like A. Analysis by Whitfield, No. 923.

C. Hornblende andesite. *Andose.* Essentially plagioclase and hornblende. Analysis by Whitfield, No. 922.

D. Hornblende-pyroxene andesite. *Tonalose.* Contains augite, hypersthene, plagioclase, and hornblende. Analysis by T. M. Chatard, record No. 712.

E. Hornblende-pyroxene andesite. *Tonalose.* Minerals as in D, with magnetite also. Analysis by Chatard, No. 712.

	A	B	C	D	E
SiO_2	55.83	57.17	55.92	56.61	60.30
Al_2O_3	17.11	17.25	17.70	13.62	16.31
Fe_2O_3	4.07	2.48	3.16	5.89	4.35
FeO	3.75	4.31	4.48	2.60	1.41
MgO	5.05	4.83	4.34	5.48	2.39
CaO	7.40	6.61	5.90	6.61	5.62
Na_2O	2.94	3.44	4.08	3.13	3.99
K_2O	1.71	2.03	2.24	2.71	2.36
H_2O-	1.28	1.20	1.42	1.20	.64
H_2O+				1.07	1.86
TiO_2	1.05	1.03	.94	.79	.76
P_2O_5	.21	.05	.18	.06	.20
Cr_2O_3	......	......	......	.05	Trace?
MnO	None.	None.	Trace.	.35	.13
BaO	......	......	......	.14	.15
SrO	......	......	......	Trace.	Trace.
Li_2O	None.	Trace.	.09	......	......
SO_3	Trace.	Trace.	Trace.	(?)	.10
Cl	None.	Trace.	None.	......	......
	100.40	100.40	100.45	100.31	100.57

F. Hornblende-mica andesite. *Yellowstonose.* Contains plagioclase, hornblende, biotite, and magnetite. Analysis by Whitfield, No. 924.

G. Hornblende-mica andesite. *Dacose.* Contains plagioclase, hornblende, and biotite. Analysis by Chatard, No. 712.

H. Dacite. *Yellowstonose.* Contains plagioclase, hornblende, biotite, and quartz. Analysis by Whitfield, No. 830.

I. Dacite. *Lassenose.* Minerals as in H. Analysis by L. G. Eakins, record No. 1135.

J. Andesite breccia. *Lassenose.* Not in paper cited. See Mon. XXXII, pt. 2. Analysis by Chatard, No. 712. Reported by Iddings as hornblende-mica andesite, containing hornblende, plagioclase, quartz. biotite, and a little magnetite.

	F	G	H	I	J
SiO_2	64.27	65.50	65.66	67.49	67.95
Al_2O_3	17.84	14.94	15.61	16.18	14.98
Fe_2O_3	3.36	1.72	2.10	1.30	2.33
FeO	1.29	2.27	2.07	1.22	.95
MgO	2.00	2.97	2.46	1.34	1.42
CaO	3.42	2.33	3.64	2.68	3.98
Na_2O	3.84	5.46	3.65	4.37	4.39
K_2O	2.48	2.76	2.03	2.40	2.86
H_2O-	1.32	.24	1.07	2.69	.37
H_2O+		1.13			.61
TiO_2	.32	.45	1.37	.13	.45
P_2O_5	.16	.09	Trace.	.13	.07
MnO	None.	.20	None.	.08	.09
BaO	......	.13	......	......	.23
SrO	......	Trace?	......	......	Trace?
Li_2O	.03	......	.36	......	......
SO_3	Trace.	.06	.13	......	.11
Cl	None.	......	.12	......	......
	100.33	100.25	100.27	100.01	100.79

3. ABSAROKA RANGE.

CRANDALL BASIN.

Rocks described by Iddings in Mon. XXXII, pt. 2. The analyses also appeared in Bull. Philos. Soc. Washington, vol. 12, p. 204.

A. Gabbro porphyry, Hurricane Ridge. *Camptonose.* Contains augite, plagioclase, hypersthene, biotite, magnetite, and a little olivine. Analysis by L. G. Eakins, record No. 1089.

B. Basalt flow, north side of Timber Creek. *Andose.* Rich in olivine, augite, and magnetite. Analysis by Eakins, No. 1087.

C. Basalt dike, ridge south of Hurricane Ridge. *Shoshonose.* Like B. Contains also labradorite and a little orthoclase. Analysis by Eakins, No. 1087.

D. Mica gabbro porphyry, Hurricane Ridge. *Camptonose.* Contains plagioclase, augite, hypersthene, biotite, and magnetite. Analysis by Eakins, No. 1089.

E. Mica gabbro, Hurricane Ridge. *Andose.* Like D, with some orthoclase and a little quartz and olivine. Analysis by Eakins, No. 1089.

F. Basalt-glass breccia, ridge south of Indian Peak. *Andose.* A glass showing crystals of olivine, augite, plagioclase, and magnetite. Analysis by Eakins, No. 1087.

	A	B	C	D	E	F
SiO_2	51.81	52.09	52.11	53.56	53.71	53.89
Al_2O_3	15.24	17.84	16.58	16.07	18.00	18.81
Fe_2O_3	3.66	4.27	3.66	3.21	3.99	4.92
FeO	4.86	4.56	4.99	5.29	4.05	2.81
MgO	8.89	5.33	6.87	7.23	5.19	3.29
CaO	9.06	8.03	6.43	8.77	6.88	5.42
Na_2O	2.83	3.39	3.25	3.06	3.50	3.65
K_2O	2.08	1.98	3.20	1.94	3.10	2.98
H_2O	.67	1.77	1.99	.19	.55	2.99
TiO_2	.77	.39	.53	.68	.74	.49
P_2O_5	.18	.27	.63	.18	.38	.52
MnO	.08	.14	.23	.11	.24	.17
	100.13	100.06	100.47	100.29	100.33	99.94

G. Orthoclase gabbro-diorite, rich in mica, Hurricane Ridge. *Andose.* Contains orthoclase, plagioclase, quartz, biotite, augite, hypersthene, magnetite, and hornblende. Analysis by Eakins, No. 1089.

H. Another sample, like G. *Andose.* Same analyst and record number.

I. Dioritic facies of gabbro, Hurricane Ridge. *Andose.* Very feldspathic. Same analyst and number.

J. Monzonite, Hurricane Ridge. *Andose.* Contains orthoclase, plagioclase, biotite, augite, hypersthene, and magnetite. Analysis by W. H. Melville, record No. 1233.

K. Augite andesite porphyry. *Andose.* Intrusive sheet, Hurricane Ridge. Analysis by Eakins, No. 1088. Contains plagioclase, augite, hypersthene, magnetite, biotite, quartz, and microscopic orthoclase.

	G	H	I	J	K
SiO_2	55.93	56.21	57.26	57.32	57.64
Al_2O_3	18.32	18.24	19.40	17.29	18.43
Fe_2O_3	2.39	3.26	2.49	3.89	3.63
FeO	4.91	3.69	3.29	3.03	2.84
MgO	3.97	3.38	2.57	3.56	3.33
CaO	6.17	5.91	5.68	5.81	5.49
Na_2O	4.29	4.15	4.21	3.89	4.03
K_2O	2.62	3.02	2.95	3.04	3.33
H_2O-	.22	.78	.86	.33	.51
H_2O+				.30	
TiO_2	.81	.88	.76	.62	.77
P_2O_5	.56	.64	.51	.50	.34
MnO	.14	.17	.16	.06	.10
NiO	....	....	....	.10	....
Cl	....	....	....	....	Trace.
	100.33	100.33	100.14	99.74	100.43

L. Hornblende-mica andesite porphyry dike, ridge south of Hurricane Ridge. *Tonalose.* Contains plagioclase, hornblende, biotite, augite, hypersthene, and magnetite, with a little chlorite or serpentine. Analysis by Eakins, No. 1087.

M. Quartz diorite porphyry, Hurricane Ridge. *Yellowstonose.* Contains plagioclase, orthoclase, quartz, augite, hypersthene, magnetite, and a little biotite. Analysis by Melville, No. 1234.

N. Quartz-mica diorite, Hurricane Ridge. *Adamellose.* Contains andesine, orthoclase, quartz, biotite, hornblende, magnetite, and a little pyroxene. Analysis by Melville, No. 1234.

O. Quartz-mica diorite porphyry, Hurricane Ridge. *Toscanose.* Contains andesine, orthoclase, quartz, and biotite. Analysis by Melville, No. 1234.

P. Aplite dike, Hurricane Ridge. *Toscanose.* Contains quartz, orthoclase, oligoclase, biotite, magnetite, some chlorite, and a little hornblende. Analysis by Eakins, No. 1088.

	L	M	N	O	P
SiO_2	61.16	63.42	63.97	64.40	71.62
Al_2O_3	16.17	17.16	13.78	15.77	14.99
Fe_2O_3	2.89	3.09	2.35	2.47	1.27
FeO	2.18	1.50	1.87	1.15	1.01
MgO	3.89	1.64	2.84	2.12	.74
CaO	4.26	4.65	3.71	3.54	1.33
Na_2O	3.87	4.51	4.36	4.10	3.62
K_2O	3.20	3.04	4.01	3.81	4.81
H_2O-	2.09	.16	.09	.31	.41
H_2O+		.28	.49	1.93	
TiO_2	.23	.35	.48	.40	.08
P_2O_5	.13	.26	.40	.16	Trace.
MnO	Trace.	.04	.05	.04	.17
NiO	....	.19	Trace.	.17	....
Cl	....	....	....	....	Trace.
	100.07	100.29	100.40	100.27	100.05

SUNLIGHT INTRUSIVES.

Descriptions supplied by Arnold Hague and T. A. Jaggar, jr. Analyses A, B, and C by W. F. Hillebrand, record No. 1801; D by H. N. Stokes, No. 1804.

A. Quartz syenite, Copper Creek Basin. *Laurvikose.* Contains biotite, hornblende, epidote, orthoclase, augite, titanite, magnetite, and apatite. Hornblende very pale in color.

B. Syenite porphyry, Sulphur Creek Basin. *Lassenose.* Contains oligoclase and biotite, in a groundmass of quartz and feldspar.

C. Augite syenite porphyry, Copper Creek Basin. *Laurvikose.* Contains augite, biotite, orthoclase, a little hornblende, and quartz.

D. Gabbro, southwest of Beams Hill, Sunlight Valley. *Andose.* Contains plagioclase, pyroxene, magnetite, apatite, and a little biotite.

	A	B	C	D
SiO_2	63.07	66.64	64.40	53.57
Al_2O_3	17.47	16.22	16.90	17.78
Fe_2O_3	2.09	1.84	1.86	3.19
FeO	1.38.	1.06	1.37	4.93
MgO	1.44	1.25	1.13	4.36
CaO	2.27	2.41	2.60	6.22
Na_2O	5.77	5.11	5.79	4.04
K_2O	4.59	3.86	4.56	3.04
H_2O-	.25	.52	.16	.27
H_2O+	.43	.55	.39	.80
TiO_2	.38	.29	.23	.89
P_2O_5	.18	.16	.21	.44
ZrO_2	Trace.	.01	.02	....
Cr_2O_3	Trace.	Trace.	(?)	None.
V_2O_3	Trace.	.01	(?)	....
NiO	None.	None.	None.	None.
MnO	.03	Trace.	.07	.07
SrO	.15	.14	.14	.13
BaO	.32	.27	.27	.21
Li_2O	Trace?	None.	Trace.	Trace.
CO_2	None.	None.	None.	None.
FeS_2	.02	Trace?	Trace?	....
	99.84	100.34	100.10	99.94

ISHAWOOA INTRUSIVES.

Descriptions supplied by Arnold Hague and T. A. Jaggar, jr. Analyses A and B by H. N. Stokes, record No. 1804; C and D by W. F. Hillebrand, No. 1765.

A. Granite porphyry, base of Crater Mountain. *Yellowstonose.* Contains oligoclase, orthoclase, biotite, and quartz.

B. Diorite porphyry, Cabin Creek. *Tonalose.* Contains plagioclase, orthoclase, quartz, and abundant hornblende. This rock is intermediate between granite porphyry and diorite porphyry, but nearer to the latter.

C. Diorite, base of Needle Mountain. *Yellowstonose.* Contains plagioclase, quartz, biotite, with subordinate hornblende and orthoclase. Structure granitic.

D. Diabase, entrance to Shoshone Canyon. *Andose.* Contains plagioclase, augite, and chlorite.

	A	B	C	D
SiO_2	64.23	60.00	63.76	52.18
Al_2O_3	16.34	16.37	16.01	18.19
Fe_2O_3	1.07	2.28	2.22	3.31
FeO	1.58	2.46	1.96	4.36
MgO	2.47	3.81	2.43	4.69
CaO	3.07	4.96	4.55	6.51
Na_2O	3.49	3.73	3.98	4.58
K_2O	2.59	2.70	2.84	1.88
H_2O-	.47	.61	.28	.75
H_2O+	1.76	1.42	.57	2.00
TiO_2	.50	.59	.52	.99
P_2O_5	.18	.35	.25	.29
NiO	None.	None.	None.	Trace.
MnO	Trace.	.05	.09	.14
SrO	.06	.11	.09	.06
BaO	.19	.26	.17	.11
Li_2O	Trace.	Trace.	Trace.	Trace.
CO_2	.30	.17	.23	None.
Cl			Trace.	Trace.
S			(?)	None.
FeS_2	1.61			
	99.91	99.87	99.95	100.04

DIKES IN BRECCIA.

Descriptions supplied by Arnold Hague and T. A. Jaggar, jr. Analyses A, B, D, by H. N. Stokes, record No. 1804; C, E, F, G, H, by W. F. Hillebrand, Nos. 1765, and 1801.

A. Hornblende-pyroxene andesite, Eagle Creek. *Camptonose.* Contains plagioclase, hornblende, pyroxene, quartz, and apatite.

B. Leucite absarokite, Sunlight Valley. *Lamarose.* Contains phenocrysts of olivine and augite, with secondary alteration of the olivine to serpentine. The groundmass contains magnetite, augite, plagioclase, and orthoclase. Leucite abundant.

C. Gabbro porphyry, Deer Creek. *Shoshonose.* Contains plagioclase, pyroxene, olivine, ilmenite, and apatite.

D. Hornblende-augite andesite, Wind River Plateau. *Tonalose.* Contains phenocrysts of augite, hypersthene, and hornblende with plagioclase and fine magnetite grains.

	A	B	C	D
SiO_2	50.72	47.32	50.29	60.15
Al_2O_3	16.01	11.22	15.85	17.85
Fe_2O_3	4.35	2.91	8.22	2.00
FeO	4.20	5.81	1.43	2.02
MgO	7.06	15.96	4.65	3.26
CaO	9.02	7.11	7.71	5.48
Na_2O	2.92	1.88	2.98	3.95
K_2O	1.13	3.79	3.53	2.36
H_2O-	.40	.31	1.77	.25
H_2O+	2.14	1.71	1.98	1.24
TiO_2	1.08	.75	.96	.47
P_2O_5	.29	.61	.51	.22
ZrO_2	....	....	....	....
Cr_2O_3	None.	Trace.	....	None.
V_2O_3	....	....	....	....
NiO	None.	Trace.	Trace.	None.
MnO	.07	.11	.15	.07
SrO	.09	.05	.09	.10
BaO	.11	.22	.15	.20
Li_2O	Trace.	Trace.	Trace.	None.
CO_2	.85	.13	None.	None.
Cl	....	....	Trace.	....
FeS_2	....	....	....	....
	100.44	99.89	100.27	99.62

E. Augite andesite, Dike Mountain. *Shoshonose.* Contains augite, plagioclase, serpentinized olivine, magnetite, and apatite.

F. Trachyte andesite, Dike Mountain. *Akerose.* Contains plagioclase, orthoclase, chlorite, apatite, and magnetite. Very little augite.

G. Biotite trachyte, Dike Mountain. *Nordmarkose.* Contains plagioclase, orthoclase, biotite, magnetite, and chlorite.

H. Biotite trachyte, Dike Mountain. *Pulaskose.* Contains orthoclase, plagioclase, biotite, and magnetite.

	E	F	G	H
SiO_2	51.17	52.47	63.24	57.73
Al_2O_3	16.14	18.23	17.98	18.93
Fe_2O_3	4.11	3.31	2.67	1.97
FeO	4.48	3.85	.85	1.92
MgO	4.82	2.85	.63	.91
CaO	7.72	4.56	.93	2.78
Na_2O	2.99	4.83	6.27	5.52
K_2O	3.54	3.81	5.47	6.11
H_2O-	.63	.68	.37	.22
H_2O+	2.24	2.03	.80	2.93
TiO_2	1.01	.97	.38	.33
P_2O_5	.48	.64	.22	.25
ZrO_2	None.	.02	Trace.	Trace.
Cr_2O_3	Trace.	Trace.	None.	Trace.
V_2O_3	.04	.03	.01	.01
NiO	.01	Trace.	None.	Trace?
MnO	.21	.15	.04	.06
SrO	.10	.11	.03	.09
BaO	.20	.23	25	.16
Li_2O	Trace.	Trace.	Trace.	Trace.
CO_2	None.	1.01	None.	.26
FeS_2	.05	.04	Trace.	.02
	99.94	99.82	100.14	100.20

4. ABSAROKITE-SHOSHONITE-BANAKITE SERIES.

Rocks from the Yellowstone Park and the Absaroka Range, described in Mon. XXXII, pt. 2, and also by Iddings in Jour. Geology, vol. 3, pp. 938, 943, 947. The rock A, from Ishawooa Canyon, is also described by Hague in Am. Jour. Sci., 3d ser., vol. 38, p. 46.

A. Leucite absarokite, Ishawooa Canyon. *Camptonose.* Bowlder. Contains olivine and augite in a groundmass of orthoclase and leucite. Accessory minerals, magnetite, apatite, and a few flakes of brown mica. Analysis by J. E. Whitfield, record No. 1057. Material dried at 104°.

B. Absarokite dike, head of Lamar River. *Lamarose.* Contains olivine and augite in a groundmass of orthoclase and plagioclase, with accessory magnetite, biotite, and ilmenite.

C. Absarokite dike, south of Clark Fork. *Absarokose.* Contains augite, quartz, biotite, magnetite, orthoclase, plagioclase, and sometimes analcite.

D. Absarokite lava flow, head of Raven Creek. *Kentallenose.* Contains olivine, augite, orthoclase, labradorite, magnetite, apatite, and a little serpentine.

E. Absarokite dike, divide east of Cache Creek. *Absarokose.* Contains orthoclase, plagioclase, augite, biotite, magnetite, serpentine, and occasional quartz.

Analyses B, C, D, and E by L. G. Eakins, record Nos. 1086, 1365.

	A	B	C	D	E
SiO_2	47.28	48.95	48.36	51.76	49.71
Al_2O_3	11.56	12.98	12.42	12.36	13.30
Fe_2O_3	3.52	3.63	5.25	4.88	4.41
FeO	5.71	4.68	2.48	4.60	3.37
MgO	13.17	11.73	9.36	9.57	7.96
CaO	9.20	7.66	8.65	7.14	8.03
Na_2O	2.73	2.31	1.46	1.99	1.49
K_2O	2.17	3.96	3.97	3.83	4.81
H_2O	2.96	3.16	5.54	3.05	4.07
TiO_2	.88	.49	1.18	.47	1.57
P_2O_5	.59	.67	.84	.56	.66
Cr_2O_3			Trace.		Trace.
MnO	.13	.13	.13	.11	.17
BaO			.29		.46
Cl	.18				
	100.03	100.35	99.93	100.32	100.01
O=Cl	.04				
	100.04				

F. Shoshonite lava sheet, Lamar River, south of Bison Peak. *Shoshonose.* Contains plagioclase, orthoclase, augite, olivine, magnetite, and serpentine, with amygdules of zeolite and calcite. Analysis by Eakins, No. 1086.

G. Shoshonite lava sheet, southeast fork of Beaverdam Creek. *Shoshonose.* Contains plagioclase, orthoclase, augite, and serpentinized olivine.

H. Leucite (?) shoshonite lava sheet, mountain east of Pyramid Peak. *Shoshonose.* Contains feldspars, olivine, serpentine, augite, magnetite, brown mica, and impure leucite (?).

I. Olivine-free shoshonite dike, northeast of Indian Peak. *Shoshonose.* Contains augite, plagioclase, biotite, and magnetite.

J. Shoshonite lava sheet, Two Ocean Pass. *Shoshonose.* Contains orthoclase, serpentinized olivine, magnetite, augite, chlorite, biotite, apatite, labradorite. Dried at 104°.

Analyses G, H, I by Eakins, Nos. 1371, 1375, 1379. Analysis J by Whitfield, No. 906.

	F	G	H	I	J
SiO_2	50.06	53.49	52.49	54.86	56.05
Al_2O_3	17.00	17.19	17.89	17.28	19.70
Fe_2O_3	2.96	4.73	5.76	4.08	3.74
FeO	5.42	3.25	2.08	2.28	2.32
MgO	3.61	4.42	3.49	4.19	2.51
CaO	8.14	6.34	7.01	5.42	4.34
Na_2O	3.53	3.23	3.18	3.94	3.29
K_2O	3.40	3.86	3.73	3.96	4.44
H_2O	4.85	2.17	2.63	2.16	1.86
TiO_2	.51	.71	.81	.69	.98
P_2O_5	.66	.43	.55	.48	.66
MnO	.14	.14	.09	.19	Trace.
BaO	....	.06	.30	.37	....
Li_2O	....	....	....	....	.06
SO_3	....	....	....	....	.19
	100.28	100.02	100.01	99.90	100.14

K. Banakite dike, head of Lamar River. *Monzonose*. Contains augite, serpentinized olivine, orthoclase, plagioclase, biotite, magnetite, ilmenite, apatite, and analcite. Adjoins rock B. Analysis by Eakins, No. 1375.

L. Banakite dike, Hoodoo Mountain. *Monzonose*. Like K, but with amygdaloidal zeolites. Analysis by Eakins, No. 1371.

M. Banakite dike, Ishawooa Canyon, Wyo. *Monzonose*. Like K and L, but more feldspathic. Contains a little serpentine, probably from olivine; also possibly analcite or sodalite. Analysis by Eakins, No. 1086.

N. Banakite dike, near head of Stinkingwater River. *Monzonose*. Like M, but with more serpentine. Analysis by W. H. Melville, record No. 1232.

	K	L	M	N
SiO_2	51.82	52.63	51.46	52.33
Al_2O_3	16.75	16.87	18.32	18.70
Fe_2O_3	4.56	4.52	4.61	4.95
FeO	3.36	3.11	2.71	1.83
MgO	4.03	3.69	2.91	2.69
CaO	4.94	4.77	6.03	4.71
Na_2O	3.91	3.86	4.11	4.51
K_2O	5.02	5.17	4.48	5.45
H_2O-	3.97	3.65	3.89	.74
H_2O+				2.71
TiO_2	.71	.81	.83	.71
P_2O_5	.52	.63	.86	.81
MnO	.23	.10	.17	.03
NiO	....	....	....	.14
BaO	.26	.29	....	....
	100.08	100.10	100.38	100.31

O. Leucite banakite lava sheet, southeast fork of Beaverdam Creek. *Shoshonose*. Overlies rock G. Contains olivine, augite, leucite, feldspars, magnetite, apatite, and a little brown mica. Analysis by Eakins, No. 1378.

P. Earlier analysis of O, another sample, by J. E. Whitfield, record No. 907.

Q. Quartz banakite dike, near head of Stinkingwater River. *Monzonose*. Contains plagioclase, orthoclase, quartz, biotite, magnetite, augite, and a little calcite. Analysis by Melville, No. 1232.

R. Quartz banakite dike, near Q. *Pulaskose*. Contains plagioclase, orthoclase, quartz, biotite, magnetite, augite, chlorite, and serpentine. Analysis by Melville, No. 1232.

	O	P	Q	R
SiO_2	52.93	51.56	57.29	60.89
Al_2O_3	19.67	21.00	18.45	17.14
Fe_2O_3	3.07	5.17	4.38	3.32
FeO	3.50	2.76	1.20	.95
MgO	2.88	2.52	2.08	1.16
CaO	4.69	4.83	3.57	3.58
Na_2O	4.20	4.37	4.43	4.54
K_2O	4.75	4.13	5.43	5.71
H_2O-	2.73	2.27	.17	.39
H_2O+			2.01	1.22
TiO_2	.72	.65	.72	.49
P_2O_5	.59	.69	.46	.27
MnO	.15	Trace.	Trace.	.09
NiO	....	....	.12	.19
BaO	.21	....	....	....
Li_2O	....	.13	....	....
SO_3	....	.21	....	....
Cl	....	Trace.	....	....
	100.09	100.29	100.31	99.94

S. Absarokite, Two Ocean Pass. *Kentallenose.* Contains augite, olivine, orthoclase, magnetite, serpentine, little biotite, apatite, and an isotropic substance, probably glass. Analysis by J. E. Whitfield, record No. 906.

T. Shoshonite, Beaverdam Creek. *Shoshonose.* Analysis by Whitfield, No. 907. Probably the rock already represented by analysis G.

U. Shoshonite, northeast spur of Sepulchre Mountain. *Shoshonose.* Contains augite and serpentinized olivine, in a groundmass of plagioclase, orthoclase, augite, magnetite, and apatite. Analysis by Whitfield, No. 908.

V. Shoshonite, Baldy Mountain, Bear Gulch, Montana. *Shoshonose.* Contains hypersthene, augite, olivine, plagioclase, orthoclase, and magnetite. Analysis by Whitfield, No. 909.

	S	T	U	V
SiO_2	51.68	52.86	51.75	54.97
Al_2O_3	14.07	17.51	17.48	18.38
Fe_2O_3	4.71	5.18	6.42	3.06
FeO	4.57	3.31	1.46	4.22
MgO	7.72	4.18	4.05	2.38
CaO	6.65	6.51	8.20	5.43
Na_2O	2.45	3.22	3.33	3.45
K_2O	4.16	3.41	3.72	3.37
H_2O	2.09	1.76	2.26	.82
TiO_2	1.08	1.04	.86	.97
P_2O_5	.72	.53	.67	.42
MnO	Trace.	Trace.	Trace.	Trace.
Li_2O	Trace.	.04	Trace.	.03
SO_3	.13	.22	.17	.03
Cl	....	.16	Trace.	Trace.
CO_2	....	....	....	2.92
	100.03	99.93	100.37	100.45

5. MISCELLANEOUS ROCKS.

First group: Collected and investigated by Arnold Hague and J. P. Iddings.

A. Black obsidian, Obsidian Cliff. *Liparose.* Described by Iddings, 7th Ann. Contains microlites of augite and magnetite, with traces of quartz and feldspar. Analysis by J. E. Whitfield, record No. 224.

B. Red obsidian, Obsidian Cliff. *Alaskose.* Described by Iddings, 7th Ann. Like A, with ferric oxide replacing magnetite. Analysis by Whitfield, No. 223.

C. Obsidian, east of Willow Park. *Lassenose.* Black and opaque. Described by Iddings, Bull. Philos. Soc. Washington, vol. 12, p. 204. Analysis by Whitfield, No. 222.

D. Lithoidite, Obsidian Cliff. *Lassenose*. Described by Iddings, Bull. 150, p. 153. Contains quartz and sanidine, with a little magnetite and augite. Analysis by Whitfield, No. 425. P. R. C. 62.

E. Rhyolite, Upper Geyser Basin. *Liparose*. See Iddings, Bull. Philos. Soc. Washington, vol. 12, p. 204. Analysis by F. A. Gooch, record No. 114.

F. Rhyolite, Tower Creek. *Toscanose*. See Iddings, Bull. Philos Soc. Washington, vol. 12, p. 204. Analysis by Gooch, No. 115.

	A	B	C	D	E	F
SiO_2	74.70	75.52	72.59	75.50	70.92	71.85
Al_2O_3	13.72	14.11	13.47	13.25	13.24	13.17
Fe_2O_3	1.01	1.74	1.58	1.02	3.54	2.17
FeO	.62	.08	1.32	.91	.66	1.34
MgO	.14	.10	1.05	.07	.23	.63
CaO	.78	.78	2.12	.90	1.42	2.25
Na_2O	3.90	3.92	4.63	4.76	4.28	4.06
K_2O	4.02	3.63	2.52	2.85	4.25	3.89
H_2O	.62	.39	.18	.41	.57	.43
TiO_2	None.	None.	.52	None.	.16	.43
P_2O_5	None.			None.	.18	.14
MnO	Trace.	None.	None.	None.	.14	.12
Li_2O				.06	None.	
SO_3				.32		
FeS_2	.40	.11	.26			
	99.91	100.38	100.24	100.05	100.59	100.48

G. Rhyolite, "Great Paint Pots." *Liparose*. Analysis by Gooch, No. 113.

H. Rhyolite, "Elephants Back." Porphyritic obsidian. *Tehamose*. Analysis by Whitfield, No. 423. Reported by Iddings as containing quartz, sanidine, and a little augite and magnetite, in a glassy, microlitic groundmass.

I. Rhyolite, Mount Sheridan. *Tehamose*. Composition reported by Iddings as quartz and sanidine, with a little magnetite and augite. Analysis by Whitfield, No. 426.

J. Sanidine quartz rhyolite, Sheridan Volcano. *Alaskose*. Analysis by G. Steiger, record No. 2154.

K. Rhyolite, Madison Plateau. Like I. *Near alaskose*. Analysis by Whitfield, No. 427.

L. Trachytic rhyolite, Elk Creek. *Lassenose*. Analysis by Whitfield, No. 428. Reported by Iddings as containing sanidine, labradorite, and little biotite, in a groundmass of quartz and alkali feldspar.

	G	H	I	J	K	L
SiO_2	75.71	75.34	75.89	77.65	75.19	64.65
Al_2O_3	11.11	12.51	12.27	11.50	13.77	17.80
Fe_2O_3	1.56	.42	1.12	1.21	.61	2.33
FeO	.37	1.55	1.37	.26	1.37	2.10
MgO	.08	.32	.29	None.	.09	.81
CaO	.88	1.07	.86	.59	.68	1.73
Na_2O	4.64	3.31	3.23	3.33	3.83	4.18
K_2O	4.18	4.17	3.42	4.83	3.33	2.83
H_2O-	.35	.86	.82	.08	.65	3.06
H_2O+				.20		
TiO_2	1.25	None.	.50	.14	None.	Trace.
ZrO_2				.03		
CO_2				None.		
P_2O_5		None.	None.	.02	None.	Trace.
SO_3		.42	.28	None.	.29	.43
MnO	.07	.07	None.	None.	Trace.	Trace.
Li_2O		Trace.	.01		.02	.17
	100.20	100.04	100.06	99.84	99.83	100.09

M. Trachytic rhyolite tuff, Two Ocean Pass. Analysis by Whitfield, No. 906. Reported by Iddings as containing sanidine, labradorite, biotite, magnetite, and augite, in a somewhat altered glassy groundmass. Also contains fragments of andesite.

N. Glassy trachyte, approaching rhyolite, Sunset Peak, Bear Gulch. *Toscanose.* Contains phenocrysts of sanidine, plagioclase, and biotite. See Iddings, Bull. Philos. Soc. Washington, vol. 12, p. 205; also Mon. XXXII, pt. 2. Analysis by L. G. Eakins, record No. 1378.

O. Altered rhyolite, "Iron Pot," Lower Basin. Collected by W. H. Weed. Analysis by Whitfield, No. 546.

P. Dacite porphyry, Echo Peak. *Near alaskose.*

Q. Same as O, Mount Holmes. *Alsbachose.*

Analyses O and P by Whitfield, Nos. 421, 422. Reported by Iddings as containing plagioclase, probably oligoclase, quartz, little biotite, and magnetite.

	M	N	O	P	Q
SiO_2	61.15	69.45	89.20	74.51	69.54
Al_2O_3	15.70	14.92	2.39	14.83	17.95
Fe_2O_3	4.31	3.16	1.21	1.09	2.50
FeO	1.12	.23	None.	Trace.	.22
MgO	3.04	.05	Trace.	.47	.50
CaO	2.84	1.19	Trace.	.81	1.80
Na_2O	1.54	3.19	1.11	4.38	4.30
K_2O	2.22	5.95	.79	2.72	1.21
H_2O	7.05	1.69	5.09	.92	1.96
TiO_2	.69	.19	None.	None.	None.
P_2O_5	.75	.06	None.	Trace.	None.
MnO	Trace.	.07	....	None.	None.
BaO	....	.03	....	....	....
Li_2O	None.	....	....	.02	Trace.
SO_3	.18	....	.44	.24	.37
	100.59	100.18	100.23	99.99	100.35

R. Mica dacite porphyry, Bunsen Peak. *Lassenose.* Analysis by Whitfield, No. 419. Reported by Iddings as containing oligoclase-andesine, quartz, biotite, little magnetite, apatite, and zircon.

S. Mica dacite porphyry, Birch Hills. *Lassenose.* Like Q in composition. Analysis by Whitfield, No. 718.

T. Hornblende-mica andesite porphyry, Fan Creek. *Yellowstonose.* Analysis by Whitfield, No. 713. Reported by Iddings as containing andesine-oligoclase, hornblende, and biotite in a groundmass of feldspar (probably oligoclase and orthoclase), with a little magnetite, biotite, and hornblende.

U. Hornblende-mica andesite porphyry, Gray Peak. *Lassenose.* Analysis by Whitfield, No. 715. Composition similar to that of S.

	R	S	T	U
SiO_2	70.52	70.24	65.63	65.64
Al_2O_3	15.85	17.36	17.00	17.29
Fe_2O_3	2.28	1.38	2.55	3.07
FeO	.36	.79	1.19	1.29
MgO	.09	.53	2.03	1.78
CaO	2.59	2.74	3.48	1.98
Na_2O	3.93	3.69	4.42	5.77
K_2O	3.43	2.65	1.64	2.44
H_2O	.35	.71	2.00	1.03
TiO_2	Trace.	Trace.	Trace.	None.
P_2O_5	.17	Trace.	.07	.23
MnO	.09	None.	None.	Trace.
Li_2O	Trace.	None.	.04	.04
SO_3	.29	Trace.	Trace.	Trace.
Cl	....	None.	Trace.	Trace.
CO_2	....	None.	.27	.17
	99.95	100.09	100.32	100.73

V. Hornblende-mica andesite, Crescent Hill. *Yellowstonose.* Analysis by Whitfield, No. 432. Reported by Iddings as containing oligoclase-andesine, biotite, and subordinate decomposed hornblende, in a groundmass of feldspar and quartz, with a little magnetite and biotite.

W. Hornblende andesite, Tower Creek. *Dacose.* Analysis by Gooch, No. 117. Reported by Iddings as containing plagioclase, hornblende, and a little augite.

X. Pyroxene andesite, Agate Creek. *Tonalose.* Analysis by Whitfield, No. 432. Reported by Iddings as containing augite, hypersthene, labradorite, and magnetite, in a glassy microlitic groundmass.

Y. Rhyolitic perlite. *Toscanose.* Described by Iddings, Bull. 150, p. 153. Analysis by H. N. Stokes, No. 1314. From a bluff opposite the Midway Geyser Basin. Reported by Iddings as containing quartz, sanidine, plagioclase, and rarely augite and magnetite, with microscopic zircon and apatite, in a glassy groundmass. P. R. C. 61.

	V	W	X	Y
SiO_2	64.61	61.56	61.45	73.84
Al_2O_3	18.62	14.73	15.07	12.47
Fe_2O_3	2.78	4.47	4.46	.32
FeO	.95	1.23	1.18	.90
MgO	.85	3.57	3.02	.25
CaO	4.20	4.87	5.37	1.08
Na_2O	4.37	5.10	4.00	2.88
K_2O	2.36	2.24	1.22	5.38
H_2O	.93	1.42	1.23	2.76
TiO_2	None.	.87	2.80	....
P_2O_5	.30	.04	Trace.	....
MnO	Trace.	.34	None.	Trace.
Li_2O	.01	....	.05	....
SO_3	Trace.	....	.29	....
Cl	Trace.	....	....	....
CO_2	.25	....	....	....
	100.23	100.44	100.14	99.88

Second group: Collected and investigated by Arnold Hague and J. P. Iddings.

A. Pyroxene andesite, west of Dunraven Peak. *Andose.* Analysis by F. A. Gooch, record No. 116. Reported by Iddings as containing labradorite, augite, hypersthene, and magnetite, in a microlitic groundmass.

B. Basalt, southwest of Dunraven Peak. *Camptonose.* Analysis by Gooch, No. 118. Reported by Iddings as containing augite, olivine, labradorite-bytownite, and magnetite, in a globulitic glassy groundmass.

C. Basalt, north spur of Prospect Peak. *Auvergnose.* Analysis by J. E. Whitfield, record No. 431. Reported by Iddings as containing labradorite, augite, olivine, and magnetite. Little glass in groundmass.

D. Basalt, Yellowstone Canyon. *Andose.* Analysis by Whitfield, No. 430. Reported by Iddings as containing labradorite-bytownite, augite, olivine, magnetite, and a little brown glass.

E. Basalt, Stinkingwater Canyon. *Andose.* See Iddings, Bull. Philos. Soc. Washington, vol. 12, p. 205. Analysis by W. H. Melville, record No. 1232.

	A	B	C	D	E
SiO_2	56.47	51.70	47.17	51.70	52.37
Al_2O_3	15.33	15.18	17.85	17.90	16.57
Fe_2O_3	2.54	2.09	7.42	7.24	6.34
FeO	4.53	8.54	1.18	1.00	2.35
MgO	5.08	8.18	6.54	2.77	5.27
CaO	6.93	8.73	10.12	6.94	8.54
Na_2O	3.81	2.31	2.94	4.17	2.99
K_2O	1.66	1.81	.56	1.62	2.45
H_2O-	1.65	.16	.65	1.15	1.18
H_2O+					1.04
TiO_2	.99	1.24	2.13	3.17	.73
P_2O_5	.54	.21	.20	.41	.31
Fe, metal (doubtful)	....	....	3.26	1.81	....
MnO	.18	Trace.	None.	Trace.	.07
NiO	....	....	....	....	.12
Li_2O	....	....	.02	.03	....
SO_3	....	....	.51	.32	....
S	....	.09	....	....	....
Cl	....	Trace.	....	....	....
	99.71	100.24	100.55	100.23	100.33

F. Camptonite (?), dike in Stinkingwater Canyon. *Andose.* See Iddings, Bull. Philos. Soc. Washington, vol. 12, p. 205. Analysis by Melville, record No. 1232.

G. Kersantite, Bighorn Pass. *Kentallenose.* Described by Iddings in Mon. XXXII, pt. 2. Contains hornblende, plagioclase, orthoclase, quartz, augite, biotite, magnetite, chlorite, calcite, and apatite. Augite and hornblende partly decomposed. Analysis by Whitfield, No. 714.

H. Basalt, dike, north spur of Mount Washburn. *Andose.* Analysis by Whitfield, No. 717. Reported by Iddings as approaching pyroxene andesite in composition. Contains labradorite, augite, serpentinized olivine, and magnetite, in a groundmass of globulitic and microlitic brown glass.

	F	G	H
SiO_2	50.99	48.73	53.75
Al_2O_3	15.62	11.92	20.75
Fe_2O_3	8.47	4.79	4.50
FeO	1.43	4.56	3.53
MgO	5.23	5.93	3.76
CaO	6.53	9.24	7.18
Na_2O	3.39	2.62	4.16
K_2O	3.05	2.47	1.37
H_2O-	1.39	1.52	1.55
H_2O+	2.48		
TiO_2	.67	1.34	None.
P_2O_5	.53	.32	.15
MnO	Trace.	.36	Trace.
NiO	.07	....	....
BaO	....	Trace.	....
Li_2O	....	Trace.	Trace.
SO_3	....	.34	Trace.
Cl	....	.11	None.
CO_2	....	5.80	None.
	99.85	100.05	100.70

MONTANA.

1. MADISON AND GALLATIN VALLEYS.

Rocks collected by A. C. Peale and G. P. Merrill. Described by Merrill in Proc. U. S. Nat. Mus., vol. 17, p. 637. See also Bull. 110, p. 47.

A. Basalt (?), east side of Bozeman Creek, 2½ miles southeast of Bozeman. *Kentallenose.* Contains olivine and augite, chloritized and serpentinized. The colorless groundmass contains apparently two feldspars and a pyroxene, with grains of iron oxide. Analysis by T. M. Chatard, record No. 517. Sp. gr., 2.86. P. R. C. 971.

B. [illegible] from A. Analysis by L. G. Eakins, record No. 1046.

C. Portion of A soluble in hydrochloric acid. Contains olivine, iron oxides, and decomposition products. Analysis by Eakins, record No. 817.

	A	B	C
SiO_2	46.90	52.50	20.88
Al_2O_3	10.17	2.26	3.89
Fe_2O_3	1.22	2.05	2.21
FeO	5.17	2.47	4.28
MgO	20.98	17.11	16.44
CaO	6.20	21.70	1.01
Na_2O	1.16	.35	Trace.
K_2O	2.04	.07	Trace.
H_2O-	1.04	.64	
H_2O+	4.38		
TiO_2	.41		
P_2O_5	.44		
Cr_2O_3	.33	1.07	
MnO	.10	Trace.	Trace.
	100.54	100.32	48.71

D. Highly altered porphyrite (?), hills 1 mile north of East Gallatin River, near camp No. 6. Rock contains hornblende paramorphs after augite in a devitrified base, with amygdules of calcite, chloritic, and ferruginous matter derived from porphyritic augite and olivine. The base is also filled with needles, which may be mica. Analysis by Eakins, record No. 820. P. R. C. 968.

E. Lamprophyre, Cottonwood Creek. *Monzonose.* Contains porphyritic augite and olivine in an indeterminate groundmass carrying augite, iron oxides, and mica. Analysis by Chatard, record No. 516. P. R. C. 979.

F. Augite porphyry, Cottonwood Creek. *Shoshonose.* Contains feldspars, augite, and brown mica, with iron oxides, apatite, glass, and secondary calcite and chlorite. Carries porphyritic plagioclase and augite. No unaltered olivine visible. Sp. gr., 2.785. Analysis by Eakins, record No. 819. P. R. C. 965.

	D	E	F
SiO_2	49.47	51.65	52.33
Al_2O_3	12.15	13.89	15.09
Fe_2O_3	1.93	2.70	4.31
FeO	4.07	4.80	4.03
MgO	10.86	11.56	6.73
CaO	9.30	4.07	7.06
Na_2O	2.08	2.99	3.14
K_2O	2.42	4.15	3.76
H_2O-	4.14	1.30	2.68
H_2O+		1.89	
TiO_2	.21	.55	.14
P_2O_5	.37	.21	1.02
Cr_2O_3	Trace.	.08	
MnO	.10	.15	.09
BaO	.03	.19	.07
SO_3		.19	
CO_2	3.31		
	100.44	100.37	100.45

G. Basalt (?), Bear Creek. *Lamarose.* Resembles A, but with a more crystalline groundmass. Contains plagioclase, possibly sanidine, augite, olivine, and iron oxides. Analysis by Chatard, record No. 1154. P. R. C. 967.

H. Lamprophyre, between South Boulder and Antelope creeks. *Kentallenose.* Contains porphyritic augite and olivine in a feldspathic groundmass, with apatite, augite, grains of iron oxide, and shreds of brown mica. Sp. gr., 2.96. Analysis by Eakins, record No. 1266. P. R. C. 966.

I. Lamprophyre, hills east of South Boulder Creek. *Near auvergnose.* Nodules from a decomposed mass. Shows sanidine, plagioclase, brown mica, and altered olivine.

	G	H	I
SiO_2	49.13	50.82	50.03
Al_2O_3	9.05	11.44	14.08
Fe_2O_3	3.57	.25	2.92
FeO	5.05	8.94	6.11
MgO	17.21	14.01	10.73
CaO	5.68	8.14	7.46
Na_2O	2.01	1.79	1.46
K_2O	2.24	3.45	2.64
H_2O-	.84	.58	3.70
H_2O+	3.50		
TiO_2	.42	.59	.61
P_2O_5	.38	.20	.42
Cr_2O_3	.39	.03	Trace.
NiO	Trace.	Trace.	Trace.
MnO	.15	.19	.08
BaO	.05	.06	.04
	99.67	100.49	100.28

J. Hornblende picrite, North Meadow Creek. *Wehrlose.* Contains hornblende, abundant fresh olivine, grains of pleonaste and iron oxides, and occasionally hypersthene. Sp. gr., 3.35. P. R. C. 973.

K. Pyroxenite, divide between Meadow and Granite creeks. *Cookose.* Contains hornblende and hypersthene, with grains of iron oxide. P. R. C. 972.

L. Hypersthene andesite, northwest of Red Bluff. *Tonalose.* Contains plagioclase and pyroxene, with an amorphous glassy base, and sometimes olivine altered to chloritic matter.

M. Peridotite, variety wehrlite, hills 3 miles northwest of Red Bluff. *Wehrlose.* Contains olivine, diallage, brown mica, rarely plagioclase, and secondary iron oxides. Sp. gr., 3.37. Analyses J, K, L, and M by Eakins, record No. 1266. P. R. C. 975 and 976.

	J	K	L	M
SiO_2	46.13	51.83	59.48	48.95
Al_2O_3	4.69	7.98	16.37	5.69
Fe_2O_3	.73	1.48	3.21	1.20
FeO	16.87	8.28	3.17	12.11
MgO	25.17	24.10	3.29	23.49
CaO	4.41	5.26	4.88	5.33
Na_2O	.08	.35	3.30	1.58
K_2O	Trace.	.06	2.81	.79
H_2O	1.38	.29	2.01	.18
TiO_2	.73	.29	.93	.81
P_2O_5	.07	.09	.41	.12
Cr_2O_3	.04	.31	.03	.05
MnO	Trace.	Trace.	.19	.08
NiO	.09	.11	Trace.	.16
BaO	Trace.		.13	Trace.
S	.24			
	100.63	100.43	100.21	100.54
Less O	.12			
	100.51			

The following rocks, at first supposed to be Pliocene sandstones, were also described by Merrill, Am. Jour. Sci., 3d ser., vol. 32, p. 119. All consist of pumiceous volcanic glass. C, from Idaho, is included here for convenience. Analyses by J. E. Whitfield, record No. 382.

A. Little Sage Creek.

B. Devils Pathway.

C. Marsh Creek Valley, Idaho.

Iron and alumina weighed together. The iron is mostly in the ferrous form.

	A	B	C
SiO_2	65.56	65.76	68.92
Al_2O_3, Fe_2O_3	18.24	17.18	16.22
MgO	.72	Trace.	Trace.
CaO	2.58	2.30	1.62
Na_2O	2.08	2.22	1.56
K_2O	3.94	3.14	4.00
H_2O-	1.12	3.46	1.60
H_2O+	6.50	5.60	6.00
	100.74	99.66	99.92

The following examples of volcanic dust or sand, from the Gallatin Valley, were collected by A. C. Peale. Analyses A, B, C, and D by F. W. Clarke, record No. 379. Analysis E by H. N. Stokes, record No. 1314.

A. Dry Creek Valley, above the mouth of Pass Creek.

B, C. Near Bozeman.

D. Near Fort Ellis.

E. Essentially rhyolitic glass, described by Iddings in Bull. 150, p. 146. Gallatin Valley. P. R. C. 58.

	A	B	C	D	E
SiO_2	46.09	61.82	71.01	60.98	68.68
Al_2O_3	14.35	19.86	15.17	21.69	12.69
Fe_2O_3					1.14
FeO					1.17
MgO	1.29	.51	.34	1.33	1.14
CaO	1.61	1.78	1.19	1.83	1.11
Na_2O	1.47	2.38	2.77	.80	1.23
K_2O		1.31	2.97	1.23	5.58
Ignition	6.45	11.47	6.34	11.96	7.99
MnO					Trace.
$CaCO_3$	28.72				
	99.98	99.13	99.79	99.82	100.73

2. THE HELENA-BUTTE REGION.

Rocks collected by W. H. Weed and G. W. Tower. Described, with three exceptions, by Weed in P. P. 74.

A. Butte granite. *Amiatose*. A quartz monzonite, variety banatite, from Walkerville Station. Contains quartz, andesine, orthoclase, hornblende, and biotite, with a little titanite, apatite, and magnetite.

B. Biotite from A.

C. Amphibole from A.

Analyses A, B, and C by H. N. Stokes, record Nos. 1686, 1808.

D. Butte granite, Gagnon mine, Butte. *Amiatose*.

E. Butte granite, Atlantic mine, Butte. *Harzose*.

F. Butte granite, Alice mine, Butte. *Harzose*.

Analyses D, E, and F by W. F. Hillebrand, record No. 1692. Mineralogically the rocks are like A and D.

G. Quartz monzonite, Frohner mine, head of Clancy Creek. *Adamellose*. Analysis by Stokes, No. 1787. Contains quartz, andesine, orthoclase, hornblende, biotite, and minor accessory minerals.

	A	B	C	D	E	F	G
SiO_2	63.88	35.79	45.73	64.05	64.34	63.87	64.17
Al_2O_3	15.84	13.70	6.77	15.38	15.72	15.39	15.25
Fe_2O_3	2.11	5.22	4.94	2.20	1.62	1.93	2.16
FeO	2.59	13.72	10.39	2.74	2.94	3.08	2.98
MgO	2.13	12.13	12.32	2.08	2.17	2.23	2.60
CaO	3.97	.05	11.25	4.30	4.24	4.30	4.24
Na_2O	2.81	.15	.77	2.74	2.76	2.76	2.62
K_2O	4.23	9.09	1.22	4.00	4.04	4.18	4.34
H_2O-	.22	1.21	.49	.27	.25	.19	.16
H_2O+	.66	3.64	2.29	.83	.76	.69	.65
TiO_2	.65	3.51	1.43	.60	.53	.65	.67
ZrO_2	....	....	....	(?)	.02	.03	....
CO_2	....	....	....	.35	.03	.15	....
P_2O_5	.21	.10	.35	.21	.14	.17	.16
MnO	.07	.19	.54	.11	.12	.11	.04
NiO	....	....	....	Trace.	Trace.	Trace.	....
BaO	.09	.13	None.	.08	.06	.07	.07
SrO	.02	None.	None.	.04	.03	.04	Trace.
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	....
SO_3	.34	....	....	....	....	....	.07
FeS_2	....	....	....	.07	.03	.07	....
Cl	Trace.	.20	....	....	....	....	Trace.
F	....	.76	.28	....	....	....	....
Cu	....	....	....	.005	.005	.005	....
	99.82	99.59	98.77	100.055	99.805	99.915	100.18
Less O	....	.37	.12	....	....	....	....
	....	99.22	98.65	....	....	....	....

The six following analyses represent alterations of quartz monzonite, the so-called Butte granite:

H. Weathered Butte granite.

I. Altered Butte granite. Decomposed near quartz-pyrite veins. Shows opaline silica, with sericite derived from feldspar. Hornblende gone; mica recognizable only as sericite masses having the form of biotite.

Analyses H and I by Stokes, record Nos. 1792, 1787.

J. Altered Butte granite, 300-foot level, Colusa mine. Derived from A. Contains quartz, altered orthoclase and plagioclase, and sericite.

K. Altered Butte granite, wall rock, 1,300-foot level, Parrot mine. Derived from A. Contains quartz, sericite, pyrite, bornite, etc.

L. Altered Butte granite, enargite vein, 1,000-foot level, Leonard mine. Contains quartz, kaolin, pyrite, etc.

M. Altered Butte granite, veinlets in Original mine. Contains quartz, sericite, partly altered feldspars, calcite, zinc blende, etc.

Analyses J, K, by E. T. Allen, record No. 1964; L, M, by W. F. Hillebrand, record No. 1971.

	H	I	J	K	L	M
SiO_2	65.14	64.81	56.80	62.09	60.90	54.30
Al_2O_3	15.63	19.44	21.02	15.49	15.83	13.63
Fe_2O_3	2.37	1.82	3.06	8.52	(?)	1.59
FeO	2.13	.16	.90	....	(?)	2.22
MgO	1.85	.19	1.21	.42	Trace.	2.13
CaO	3.62	.18	.35	.20	.06	7.36
Na_2O	2.63	.21	.50	.37	.08	.16
K_2O	4.29	5.30	4.78	4.34	.08	4.41
H_2O-	.37	1.41	2.88	1.20	.87	2.19
H_2O+	.75	5.25	7.68	3.01	3.88	4.09
TiO_2	.59	.73	.60	.51	.68	.61
CO_2	None.	None.	None.	None.	None.	5.50
P_2O_5	.16	.10	.05	.13	....	.20
S	....	....	.17	5.47	5.46	....
SO_3	.05	.31	None.	None.	None.	None.
FeS_2	....	....	....	....	....	.49
Cr_2O_3	....	....	Trace.	None.	....	....
MnO	Trace.	Trace.	Trace.	Trace?	None.	.71
SrO	Trace.	Trace.	....	....	....	....

	H	I	J	K	L	M
BaO	0.10	0.10	0.05	Trace.	....	Trace.
Li_2O	Trace.	Trace.	....	....	....	....
ZnO	....	....	....	....	....	.12
Fe, total iron	....	....	....	....	4.37	....
Cu	....	....	.10	.25	Present.	....
	99.68	100.01	100.15	102.00	98.15	100.01
Less O	....	....	.06	2.05	....	....
	....	....	100.09	99.95	....	....

N. "Bluebird granite," Nettie mine. *Alaskose*. An aplite. Contains orthoclase and quartz, with a little plagioclase and a sprinkling of biotite. Analysis by H. N. Stokes, record No. 1686.

O. Same rock and locality as M. Analysis by W. F. Hillebrand, record No. 1692.

P. Dacitic pitchstone, Butte. *Lassenose*. Phenocrysts of andesine, quartz, and orthoclase in a glassy base.

Q. Rhyolite, Hyde Park dike. *Tehamose*. Contains sanidine, quartz, plagioclase, and biotite in a groundmass of quartz and feldspar. Analyses P, Q, by Stokes, record No. 1686.

R. Quartz porphyry, Modoc mine. *Toscanose*. Contains quartz, orthoclase, and plagioclase in a groundmass of quartz and feldspar. A few small biotites are present. Feldspar partly altered to sericite. Analysis by Hillebrand, record No. 1692.

S. Altered rhyolite porphyry, 1,800-foot level, Anaconda mine. Contains quartz phenocrysts, with sericite, pyrite, etc. Analysis by Hillebrand, record No. 1971, partial only.

	N	O	P	Q	R	S
SiO_2	76.87	77.65	67.55	74.34	69.95	71.01
Al_2O_3	12.52	12.84	15.68	12.97	15.14	14.37
Fe_2O_3	.67	.56	.98	.75	.38	.18
FeO	None.	.14	1.02	.54	.83	.26
MgO	.09	Trace.	1.11	.86	.56	.58
CaO	.49	.57	2.51	.85	1.45	.10
Na_2O	2.47	2.81	4.15	2.49	2.70	1.56
K_2O	5.78	5.52	2.86	4.72	6.36	4.53
H_2O-	.25	.22	.38	1.03	.40	....
H_2O+	.52	.48	2.76	1.11	.91	....
TiO_2	.11	.12	.34	.18	.24	.24
ZrO_2	....	....	None.	.05	.02	....
CO_2	....	....	None.	None.	.37	....
P_2O_5	.05	None.	.12	.07	.10	....
S	Trace.	....	....	....	....	....
SO_3		....	None.	.03	....	....
FeS_2	....	....	....	....	[a] .39	4.37
Cl	None.	....	.05	None.	Undet.	....
MnO	Trace.	None.	Trace.	Trace.	.08	Trace?
SrO	None.	None.	.03	Trace.	.02	....
BaO	None.	None.	.11	.07	.13	....
Li_2O	Trace.	Trace.	None.	Trace.	Trace.	....
Cu	....	....	....	....	.03	....
	99.82	100.31	99.65	100.06	100.06	97.20

[a] Other sulphides than pyrite are present.

T. Granite, Boulder type, near Boulder. Near adamellite. *Toscanose*. Contains quartz, feldspar, black mica, and dark-green hornblende. Has an unusual amount of plagioclase.

U. Rock from contact of granite with limestone, Red Mountain. *Andose*. Contains pale-green to colorless hornblende, plagioclase varying from labradorite to albite, some orthoclase, and a little quartz. Biotite, apatite, and magnetite also occur.

V. Rock from contact of granite with limestone, Red Mountain. *Kentallenose*. Consists mainly of green hornblende and "basic" plagioclase. Little quartz present.

W. Diorite, Red Rock Creek. *Harzose.* Contains hornblende, augite, biotite, plagioclase, and orthoclase, with a little magnetite and apatite.

Analyses by H. N. Stokes, record Nos. 1686, 1787.

	T	U	V	W
SiO_2	67.12	56.41	49.22	61.64
Al_2O_3	15.00	17.62	12.02	15.63
Fe_2O_3	1.62	1.24	2.77	3.39
FeO	2.23	3.55	8.80	2.69
MgO	1.74	3.97	9.29	2.52
CaO	3.43	8.66	10.56	4.90
Na_2O	2.76	3.25	1.90	2.64
K_2O	4.52	2.61	1.70	3.72
H_2O-	.09	.14	.27	.28
H_2O+	.58	.76	1.63	.91
TiO_2	.48	.68	.95	.71
P_2O_5	.15	.49	.43	.21
Cr_2O_3	None.	....	....	Trace.
MnO	.06	.08	Trace.	.04
SrO	.03	.08	.03	.04
BaO	.07	.09	.03	.08
Li_2O	Trace.	None.	Trace.	Trace.
S	....	None.	.05	....
SO_3	Trace.	None.	.01	None.
Cl	....	.07	.08	....
	99.88	99.70	99.77	99.70

The three following analyses do not appear in Weed's report.

X. Rhyolite, top of Red Mountain, Rimini. *Liparose.* Quartz and feldspar phenocrysts in a groundmass of the same minerals.

Y. Andesite porphyry, Hiawatha Creek above basin. *Amiatose.* Contains plagioclase, orthoclase, and augite.

Z. Andesite porphyry, Zosel mining district, near Daylight. *Near bandose.* Somewhat altered. Contains augite, andesine, and olivine in a groundmass of plagioclase, augite, and iron oxide. Ferromagnesian minerals altered to serpentine. Analyses by H. N. Stokes, record Nos. 1686, 1787.

	X	Y	Z
SiO_2	75.30	62.53	54.61
Al_2O_3	11.95	19.01	15.23
Fe_2O_3	2.17	1.96	3.51
FeO		1.44	4.80
MgO	.05	1.29	4.69
CaO	.62	5.17	7.41
Na_2O	3.09	3.45	1.46
K_2O	4.96	3.30	2.70
H_2O-	.36	.21	.32
H_2O+	.61	.45	2.47
TiO_2	.17	.65	.86
P_2O_5	Trace.	.17	.35
ZrO_2	....	....	None.
MnO	Trace.	.03	.09
SrO	None.	.04	.04
BaO	Trace.	.13	.11
Li_2O	Trace.	Trace.	Trace.
CO_2	None.	None.	1.46
SO_3	.44	None.	None.
FeS_2	....	....	....
Cl	Trace.	....	None.
Organic matter	.45	....	....
	100.17	99.83	100.11

The following rocks were collected by Adolph Knopf, and described in Bull. 527. Analyses by J. G. Fairchild, record Nos. 2645, 2654.

A. Quartz monzonite, King Solomon's mine, Clancy. *Adamellose.* Contains andesine, orthoclase, quartz, biotite, and hornblende.

B. Altered quartz monzonite, King Solomon's mine. Contains quartz, orthoclase, sericite, and pyrite.

C. Quartz monzonite, Valley Forge mine, Rimini. *Toscanose.* Contains the same minerals as in A.

D. Altered quartz monzonite. Contains quartz, sericite, and pyrite, with subordinate tourmaline.

E. Altered quartz monzonite. Contains quartz, sericite, and pyrite, with accessory galena and sphalerite.

F. Latite, Thunderbolt Creek. *Amiatose.* Contains phenocrysts of andesine and occasional hornblende in a glassy groundmass.

The andesine in these rocks is near Ab_1An_1.

	A	B	C	D	E	F
SiO_2	64.49	71.22	65.91	66.70	66.02	64.45
Al_2O_3	15.49	15.05	15.32	13.25	14.14	17.69
Fe_2O_3	1.28	Trace.	2.28	1.34	1.53	1.33
FeO	2.71	1.54	2.02	.51	.37	1.93
MgO	1.89	.33	1.52	.30	.67	.57
CaO	4.32	None.	3.28	.05	.26	3.73
Na_2O	3.53	.42	3.08	.39	.39	3.85
K_2O	4.04	6.99	4.80	4.03	4.63	3.68
H_2O-	.16	.32	.60	.08	.10	.59
H_2O+	.48	1.52	.60	.37	.48	.80
TiO_2	.56	.31	.59	.20	.56	.69
CO_2	.49	1.50	.21	.21	.25	.29
P_2O_5	.19	.08	.18	.12	.17	.16
S	.07	......	.02	......	......	.04
F	......	......	......	......	.02	......
MnO	.07	.05	Trace.	Trace.	Trace.	.05
BaO	.06	None.	.10	None.	.04	.19
PbS	......	......	......	.59	2.02	......
ZnS	......	......	......	1.86	.74	......
FeS_2	......	.45	......	5.09	6.73	......
FeAsS	......	......	......	4.75	.72	......
	99.83	99.78	100.51	99.84	99.84	100.04
Specific gravity	2.714	2.599	2.651	2.979	2.893	......

3. CRAZY MOUNTAINS.

The greater number of the rocks in this group were received from J. E. Wolff, who has supplied the petrographic data. The few exceptions are properly indicated. The three tinguaites and the elæolite syenite were described by Wolff and Tarr in Bull. Mus. Comp. Zool., vol. 16, No. 12, 1893, in a paper upon "Acmite-Trachyte from the Crazy Mountains." The renaming of these rocks is due to Wolff. The analyses, except when otherwise stated, are by W. F. Hillebrand, record No. 1438.

A. Granitite, Big Timber Creek. *Toscanose.* Small dikes in main diorite stock. Contains quartz, orthoclase, plagioclase (oligoclase), and biotite. P. R. C. 1720.

B. Hornblende granitite, main stock, Big Timber Creek. *Dacose.* Contains biotite, hornblende, quartz, orthoclase, and plagioclase (oligoclase). P. R. C. 1721.

C. Granite porphyry, intrusive sheet, north part of the mountains. *Lassenose.* Contains orthoclase, albite, quartz, biotite, and green hornblende in a groundmass of quartz and untwinned feldspar. P. R. C. 1722.

D. Porphyrite, intrusive sheet, Sweet Grass Creek. *Lassenose.* Contains hornblende and andesine in a groundmass of plagioclase, orthoclase, and quartz, with accessory magnetite. P. R. C. 1723.

E. Porphyrite, dike in contact zone, Sweet Grass Creek. *Toscanose.* Contains brown hornblende, biotite, and labradorite in a groundmass of plagioclase, biotite, and hornblende, with a little quartz and orthoclase. P. R. C. 1724.

F. Porphyrite, intrusive sheet, middle peak of Three Peaks. *Akerose.* Contains andesine, hornblende, augite, and biotite in a groundmass of plagioclase, orthoclase, and quartz. P. R. C. 1725.

	A	B	C	D	E	F
SiO_2	74.37	64.47	69.93	66.28	64.49	61.08
Al_2O_3	13.12	15.45	14.95	16.21	17.25	16.62
Fe_2O_3	.73	2.25	1.78	.80	.86	2.87
FeO	.87	2.25	.55	2.06	2.42	2.56
MgO	.35	2.68	.60	1.57	1.24	1.65
CaO	1.26	3.63	1.46	3.53	3.79	3.66
Na_2O	2.57	4.54	5.30	4.36	4.19	4.75
K_2O	6.09	3.19	3.99	3.20	4.15	3.90
H_2O-	.05	.05	.12	.12	.06	.44
H_2O+	.25	.63	.32	.78	.54	.97
TiO_2	.29	.75	.33	.50	.51	.73
P_2O_5	.06	.22	.33	.20	.23	.03
MnO	Trace.	.06	Trace.	Trace.	Trace.	Trace.
SrO	Trace.	.04	.06	.05	.08	.08
BaO	.10	.23	.29	.34	.30	.32
Li_2O	Trace.	Trace?	Trace.	Trace?	Trace.	Trace.
	100.11	100.44	100.01	100.00	100.11	100.26

G. Porphyrite, intrusive sheet, north of Shields River Basin. *Akerose.* Contains plagioclase, hornblende, and biotite, in a groundmass of plagioclase, a little orthoclase, augite, hornblende, and magnetite. P. R. C. 1726.

H. Porphyrite, intrusive sheet, northern part of the mountains. *Akerose.* Contains brown hornblende, green augite, and plagioclase, in a groundmass of plagioclase, augite, and magnetite, with accessory apatite. P. R. C. 17127.

I. Syenite, ridge north of Shields River Basin. *Akerose.* Contains hornblende, green augite, and anorthoclase, with accessory sphene, apatite, and magnetite. P. R. C. 1728.

J. Diabase-porphyrite (?), dike south of Shields River Basin. *I. 5. 3. 4.* Contains labradorite and decomposed augite in a groundmass of plagioclase, epidote, and chlorite. P. R. C. 1729.

K. Diorite-porphyrite, Big Timber Creek. *Andose.* Contains labradorite, augite, hornblende, biotite, orthoclase, quartz, magnetite, and apatite. P. R. C. 1730.

L. Quartz diorite, main stock on Sweet Grass Creek. *Andose.* Contains hornblende, biotite, augite, labradorite, orthoclase, and quartz, with accessory apatite, magnetite, olivine, and hypersthene. P. R. C. 1731.

	G	H	I	J	K	L
SiO_2	56.75	54.69	58.28	58.28	54.56	53.48
Al_2O_3	16.40	16.53	17.89	19.37	17.58	19.35
Fe_2O_3	4.78	4.54	3.20	1.35	4.30	2.37
FeO	3.10	2.83	1.73	2.98	4.98	4.90
MgO	3.22	2.99	1.51	1.30	2.86	3.67
CaO	5.34	5.34	3.69	4.78	6.00	7.55
Na_2O	4.19.	5.19	5.89	4.40	4.43	4.07
K_2O	3.36	3.93	5.34	3.75	2.70	1.41
H_2O-	.40	.32	.17	.44	.02	.16
H_2O+	.82	1.05	.98	1.78	.38	.80
TiO_2	.86	.91	.64	.96	1.34	1.07
P_2O_5	.52	.73	.26	.35	.60	.62
MnO	.17	.07	.06	.07	.06	.06
SrO	.10	.06	.05	.09	.08	.11
BaO	.33	.37	.36	.25	.27	.19
Li_2O	Trace?	Trace?	Trace.	Trace?	Trace.	Trace?
Cl	....	Trace.	....	....	....	....
CO_2	....	.83	....	.33	....	.08
	100.34	100.38	100.05	100.48	100.16	99.89

M. Diorite, head of Rock Creek. *Shoshonose.* Contains biotite, labradorite, and augite, in a groundmass of plagioclase, orthoclase, and quartz, with accessory magnetite, apatite, and hornblende. P. R. C. 1732.

N. Diorite, main stock, Big Timber Creek. *Andose.* Contains biotite, augite, labradorite, quartz, orthoclase, apatite, and magnetite. P. R. C. 1733.

O. Olivine gabbro, Big Timber Creek. *IV. 2^2. 1^2. 2.* Contains labradorite (?), brown hornblende, augite, olivine, and magnetite. P. R. C. 1734.

P. Rock from Musselshell River, north of Crazy Mountains. *Monchiquose.* Received from J. S. Diller, but undescribed. Regarded by W. H. Weed as monchiquite. Analysis by L. G. Eakins, record No. 1021.

Q. Hornstone, metamorphosed shale, contact zone, Sweet Grass Creek. An aggregate of augite, quartz, triclinic feldspar, and biotite. P. R. C. 1735.

	M	N	O	P	Q
SiO_2	57.97	50.73	40.42	44.66	57.31
Al_2O_3	15.65	19.99	9.98	12.12	14.24
Fe_2O_3	.73	3.20	9.83	5.81	1.00
FeO	2.80	4.66	10.67	3.20	3.24
MgO	4.96	3.48	11.56	8.77	4.60
CaO	10.93	8.55	10.78	8.14	11.31
Na_2O	3.03	4.03	1.26	4.47	2.64
K_2O	3.16	1.89	.60	2.75	4.55
H_2O-	.22	.11	.45	4.33	.25
H_2O+	.38	.66	1.17		.24
TiO_2	.60	1.59	2.51	1.02	.52
P_2O_5	.15	.81	.63	2.02	.18
(CoNi)O	....	....	.02	....	....
MnO	Trace.	.05	.25	.21	.08
SrO	.02	.11	.02	....	Trace?
BaO	.09	.27	.05	....	.19
Li_2O	Trace.	Trace.	Trace.	....	Trace?
CO_2	....	....	....	2.19	.17
Cl	Trace.	....	....	....	....
F	Trace.	....	....	....	....
	100.69	100.13	100.20	99.69	100.52

R. Elæolite syenite, Peaked Butte, northeast side of the mountains. *Umptekose.* Described by Wolff and Tarr, loc. cit. Contains anorthoclase, augite, occasionally sodalite, ægirine, apatite, magnetite, and some interstitial nephelite. Analysis by W. H. Melville, record No. 1291. P. R. C. 1736.

Ra. Anorthoclase from R. Analysis by W. F. Hillebrand, record No. 1297.

S. Tinguaite, var. sölvsbergite, intrusive sheet north of Shields River. P. R. C. 1737.

T. Tinguaite, var. sölvsbergite, dike north part of mountains. *Nordmarkose* P. R. C. 1738.

U. Tinguaite, var. sölvsbergite, dike at head of Sixteenmile Creek. *Nordmarkose.* P. R. C. 1739.

S, T, and U are the rocks described by Wolff and Tarr in their paper upon "Acmite Trachyte." Mineral composition the same as under R. Analyses by W. H. Melville, record No. 1291.

	R	Ra	S	T	U
SiO_2	59.66	62.31	58.70	62.17	64.33
Al_2O_3	16.97	22.63	19.26	18.58	17.52
Fe_2O_3	3.18	....	3.37	2.15	3.06
FeO	1.15	....	.58	1.05	.94
MgO	.80	....	.76	.73	.34
CaO	2.32	.63	1.41	1.57	.56
Na_2O	8.38	7.68	8.55	7.56	7.30
K_2O	4.17	4.79	4.53	3.88	4.28
H_2O-	.07	.16	.07	.07	.04
H_2O+	2.53	.72	2.57	1.63	.95
TiO_2	Trace.	....	Trace.	Trace.	Trace.
P_2O_5	.14	....	.10	.11	Trace.
MnO	.19	....	.10	Trace.	.35
SrO	....	.57	....	....	....
BaO	....	.77	....	....	....
	99.56	100.26	100.00	99.50	99.67

V. Theralite, Gordons Butte. *Malignose.* Contains green augite, ægirine, biotite, olivine, nephelite, sodalite, and a feldspar, partly sanidine, containing K, Na, Ba, Sr, and Ca; also accessory apatite, magnetite, and sphene.

W. Theralite, Gordons Butte; another sample. *Kamerunose.* Analysis by E. A. Schneider, record No. 1281. P. R. C. 75.

X. Theralite, north of Alabaugh Creek. *Essexose.* Described by Wolff for the Educational Series (Bull. 150). Contains augite, ægirine, biotite, olivine, magnetite, apatite, nephelite partly zeolitized, a mineral of the sodalite group, sanidine, and analcite. Analysis by Schneider, No. 1281. P. R. C. 76.

Rocks V, W, and X are described by Wolff in Bull. 150, pp. 197, 199.

Y. Altered theralite, head of Shields River, west of Loco Mountain. Received from W. H. Weed. Analysis by H. N. Stokes, record No. 1547.

Z. Hornblende picrite, Conical Peak. *Auvergnose.* Data supplied by J. P. Iddings. Contains hornblende, plagioclase, hypersthene, augite, olivine, very little primary quartz, and probably some magnetite and apatite. Analysis by L. G. Eakins, record No. 1379.

	V	W	X	Y	Z
SiO_2	44.65	44.31	47.67	48.90	45.71
Al_2O_3	13.87	17.20	18.22	14.70	10.80
Fe_2O_3	6.06	4.64	3.65	4.14	4.43
FeO	2.94	3.73	3.85	3.68	9.35
MgO	5.15	6.57	6.35	3.95	13.75
CaO	9.57	10.40	8.03	8.26	10.48
Na_2O	5.67	4.45	4.93	5.22	1.58
K_2O	4.49	3.64	3.82	.56	.85
H_2O-	.96	.77	.38	.52	.97
H_2O+	2.10	3.30	2.97	2.44	
TiO_2	.95	Undet.	Undet.	.95	1.83
P_2O_5	1.50	....	....	.79	.11
Cr_2O_3	....	....	....	....	.10
MnO	.17	.10	.28	.03	.17
SrO	.37	....	....	.13	....
BaO	.76	....	....	.31	Trace.
Li_2O	Trace.	....	....	Trace.	....
CO_2	.11	....	....	5.42	....
SO_3	.61	....	....	.04	....
Cl	Trace.	....	....	....	....
	99.93	99.11	100.15	100.04	100.13

4. LITTLE BELT MOUNTAINS.

Rocks collected by W. H. Weed and L. V. Pirsson. Described in a paper on the Neihart and Barker mining districts in Pt. III of the 20th Ann. Analyses by W. F. Hillebrand, record No. 1476, and H. N. Stokes, record No. 1547.

A. Rhyolite porphyry, Yogo Peak, sheet at head of Belt and Running Wolf creeks. *Toscanose.* Phenocrysts of orthoclase and quartz in a groundmass of quartz and alkali feldspar, with a little white mica and some kaolin. Chlorite, limonite, and calcite are also present, pseudomorphous after biotite and perhaps hornblende. Total amount of secondary minerals very small. Analysis by Hillebrand. P. R. C. 1474.

B. Granite porphyry, Wolf Butte. *Toscanose.* Phenocrysts of quartz, orthoclase, plagioclase, and biotite in a groundmass of quartz and alkali feldspar. A little apatite and iron ore, with secondary calcite, limonite, chlorite, and white mica. Analysis by Stokes. P. R. C. 1475.

C. Granite porphyry, top of Barker Mountain. *Toscanose.* Phenocrysts of orthoclase, oligoclase, biotite, green hornblende, sphene, and iron ore in a groundmass of quartz and alkali feldspar. Also a little apatite and some secondary chlorite and limonite. Analysis by Stokes. P. R. C. 1476.

D. Syenite, Wright and Edwards mine, Hughesville, near Barker. *Toscanose.* Very fresh rock. Contains magnetite, ilmenite, hornblende, anorthoclase, albite, subordinate quartz, a little chlorite, calcite, and limonite, and white mica in traces. Analysis by Stokes. P. R. C. 1477.

E. Syenite, Yogo Peak. *Monzonose.* Described in Am. Jour. Sci., 3d ser., vol. 50, p. 471. Contains apatite, sphene, iron ore, pyroxene, hornblende, biotite, orthoclase, oligoclase, and quartz, with traces of chlorite and limonite and a little kaolin. Analysis by Hillebrand. P. R. C. 1478.

F. Granite porphyry, dike at head of Sheep Creek. *Toscanose.* Phenocrysts of orthoclase, some plagioclase, and green hornblende, in a groundmass of alkali feldspar, with some quartz. Also contains a little apatite and iron ore, with some secondary calcite and kaolin. Analysis by Hillebrand. P. R. C. 1479.

	A	B	C	D	E	F
SiO_2	73.12	69.68	68.60	64.64	61.65	66.29
Al_2O_3	14.27	14.97	16.13	16.27	15.07	15.09
Fe_2O_3	.51	.79	2.22	2.42	2.03	1.37
FeO	.26	.34	.44	1.58	2.25	1.17
MgO	.24	.66	.72	1.27	3.67	2.39
CaO	1.10	2.10	1.36	2.65	4.61	2.38
Na_2O	3.43	3.38	4.37	4.39	4.35	3.96
K_2O	4.90	4.40	4.89	4.98	4.50	4.91
H_2O-	.68	1.09	.20	.09	.26	.39
H_2O+	.73	.92	.58	.27	.41	.60
TiO_2	.08	.28	.32	.51	.56	.27
P_2O_5	.03	.17	.18	.37	.33	.15
Cr_2O_3	None.	....	....	....	Trace.	None.
MnO	.06	Trace.	Trace.	Trace.	.09	.06
SrO	Trace.	.06	.09	.08	.10	.07
BaO	Trace.	.14	.27	.18	.27	.30
Li_2O	Trace.	Trace.	Trace.	....	Trace.	Trace.
CO_2	.77	.88	....	.37	....	.45
SO_3	....	Trace.	Trace.	Trace.	....	....
Cl	....	Trace.	Trace.	.05	....	....
	100.18	99.86	100.37	100.12	100.15	99.85

G. Syenite porphyry, intrusive sheet, between Yogo Peak and Big Baldy Mountain. *Lassenose.* Abundant phenocrysts of hornblende and orthoclase, with less biotite and plagioclase, in a groundmass of alkali feldspar with accessory quartz. Also contains iron ore and apatite, with secondary calcite, chlorite, sericite, and kaolin. Analysis by Hillebrand. P. R. C. 1480.

H. Granite porphyry, north end of Thunder Mountain. *Toscanose.* Phenocrysts of orthoclase, oligoclase, hornblende, and biotite, in a groundmass of alkali feldspar and very abundant quartz. Also contains a little sphene, iron ore, and apatite, very little secondary chlorite and limonite, and a trace of kaolin. Analysis by Stokes. P. R. C. 1481.

I. Granite porphyry, top of Big Baldy Mountain. *Toscanose.* Phenocrysts of orthoclase, plagioclase, biotite, iron ore, brown hornblende, and sphene, in a groundmass of quartz and alkali feldspar. Also contains a little apatite, with traces of chlorite, limonite, and kaolin. Analysis by Hillebrand. P. R. C. 1482.

J. Quartz monzonite, talus slope on west side of Bear Park. *Dacose.* Phenocrysts of biotite, hornblende, plagioclase, and orthoclase, in a groundmass of quartz and alkali feldspar. Also contains a little magnetite, chlorite, white mica, and apatite. Analysis by Stokes. P. R. C. 1483.

K. Diorite porphyry, Steamboat Mountain. *Adamellose.* Phenocrysts of orthoclase, plagioclase, hornblende, and biotite, with a little iron ore and apatite, in a groundmass of orthoclase, plagioclase, and quartz. Analysis by Stokes. P. R. C. 1484.

L. Diorite, Carpenter Creek, near Neihart. *Andose.* Contains green hornblende, biotite, and plagioclase, with some apatite, iron ore, calcite, kaolin, and muscovite, and a very little quartz and orthoclase. Analysis by Hillebrand. P. R. C. 1485.

	G	H	I	J	K	L
SiO_2	62.58	67.44	67.04	65.95	62.18	55.13
Al_2O_3	16.42	15.78	15.25	15.44	15.77	20.27
Fe_2O_3	2.46	1.58	1.69	2.02	1.83	1.52
FeO	1.96	.85	1.13	1.60	2.44	4.29
MgO	1.84	1.43	1.75	2.65	3.55	1.80
CaO	2.47	2.38	2.17	3.07	4.13	7.05
Na_2O	4.57	4.11	4.09	4.25	3.92	4.31
K_2O	3.91	4.87	5.10	3.87	3.91	2.84
H_2O-	.38	.32	.56	.26	.30	.14
H_2O+	1.40	.70	.51	.85	.70	.95
TiO_2	.40	.32	.20	.39	.55	.74
P_2O_5	.33	.21	.21	.25	.32	.40
MnO	.08	Trace.	.05	Trace.	Trace.	.13
SrO	.10	.09	.03	.10	.16	.06
BaO	.41	.24	.33	.35	.43	.11
Li_2O	Trace.	Trace.	Trace?	....	Trace.	Trace.
CO_2	.77	....	....	....	....	.26
SO_3	....	Trace.	....	.02	Trace.	....
Cl	....	Trace.	....	.04	.04	....
	100.08	100.32	100.11	100.11	100.23	100.00

M. Minette, intrusive sheet, head of Sheep Creek. *Monzonose.* Chiefly biotite, augite, and orthoclase, with accessory apatite, plagioclase, quartz, and iron ore, and some secondary calcite, chlorite, and kaolin. Analysis by Hillebrand. P. R. C. 1486.

N. Monzonite, Yogo Peak. *Monzonose.* Described in Am. Jour. Sci., 3d ser., vol. 50, p. 473, and 4th ser., vol. 1, p. 356. Contains apatite, sphene, iron ore, pyroxene, hornblende, biotite, orthoclase, and oligoclase, and a little secondary kaolin. Analysis by Hillebrand. P. R. C. 1487.

O. Monchiquite, dike on Big Baldy Mountain. *Monchiquose.* Contains much pyroxene, a few serpentinized olivines, iron ore, and apatite in a colorless base of analcite. Analysis by Hillebrand. P. R. C. 1488.

P. Monchiquite, dike on Bandbox Mountain. *Near wyomingose.* Contains olivine, augite, biotite, analcite, and apatite, with traces of serpentine and chlorite. Analysis by Stokes. P. R. C. 1489.

Q. Shonkinite, Yogo Peak. *Shonkinose.* Described in Am. Jour. Sci., 3d ser., vol. 50, p. 474. Chiefly augite and orthoclase, with a considerable amount of accessory biotite, iron ore, and andesine, less apatite and olivine, and a trace of kaolin. Analysis by Hillebrand. P. R. C. 1490.

	M	N	O	P	Q
SiO_2	52.26	54.42	48.35	48.39	48.98
Al_2O_3	13.96	14.28	13.27	11.64	12.29
Fe_2O_3	2.76	3.32	4.38	4.09	2.88
FeO	4.45	4.13	3.23	3.57	5.77
MgO	8.21	6.12	8.36	12.55	9.19
CaO	7.06	7.72	9.94	7.64	9.65
Na_2O	2.80	3.44	3.35	4.14	2.22
K_2O	3.87	4.22	3.01	3.24	4.96
H_2O-	1.53	.22	.90	.28	.26
H_2O+	1.34	.38	2.89	2.56	.56
TiO_2	.58	.80	.52	.73	1.44
P_2O_5	.52	.59	.40	.45	.98
Cr_2O_3	Trace.	Trace.	Trace.	.07	Trace.
NiO	....	....	.04	....	....
MnO	.14	.10	.19	Trace.	.08
SrO	.05	.13	.09	.15	.08
BaO	.23	.32	.54	.32	.43
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.
SO_3	....	....	....	.08	....
Cl	....	....	....	Trace.	....
CO_2	.49	....	.30	....	....
F	....	....	.25	....	.22
	100.25	100.19	100.01	99.90	99.99

5. CASTLE MOUNTAIN DISTRICT.

Rocks described by Weed and Pirsson in Bull. 139. Analyses made by Pirsson in the laboratory of the Sheffield Scientific School.

A. Rhyolite, between Fourmile and Fivemile creeks, near Smith River. *Liparose.* Contains quartz, soda orthoclase, tourmaline, and a little iron ore and zircon. P. R. C. 560.

B. Quartz-tourmaline porphyry, upper Fourmile Creek. *Liparose.* Contains quartz, orthoclase, plagioclase, tourmaline, fluorite, and a little white mica, apatite, and zircon. P. R. C. 558.

C. Granite, Elk Peak. *Liparose.* Contains quartz, orthoclase, oligoclase, biotite, hornblende, iron ore, apatite, sphene, and zircon. The last three minerals are rare. P. R. C. 551.

D. Quartz porphyry, sheet or ridge between Fourmile and Checkerboard creeks. *Liparose.* Contains quartz, plagioclase, an untwinned feldspar and biotite, with occasional grains of iron ore and crystals of apatite and zircon. P. R. C. 557.

E. Rhyolite-pitchstone, forks of Checkerboard Creek. *Kallerudose.* Essentially glass, inclosing grains of iron ore. P. R. C. 561.

F. Aplitic granite, dike between Blackhawk and Robinson. *Liparose.* Contains quartz and unstriated feldspar, some plagioclase, and occasional biotite. P. R. C. 553.

G. Quartz porphyry, Musselshell Canyon. *Liparose.* Contains quartz, biotite, plagioclase, apatite, iron ore, and zircon. P. R. C. 556.

	A	B	C	D	E	F	G
SiO_2	74.90	74.82	72.48	72.38	72.56	72.88	71.67
Al_2O_3	13.64	13.80	13.14	14.71	12.33	12.90	15.82
Fe_2O_3	.66	.37	1.66	1.09	.80	.74	1.18
FeO	.50	.30	1.02	.82	.82	1.05	.35
MgO	Trace.	.10	.15	.70	Trace.	.75	.13
CaO	.61	.17	1.04	.67	Trace.	.81	.25
Na_2O	4.22	4.33	4.22	4.28	5.36	3.72	4.46
K_2O	4.64	4.81	4.88	4.15	3.08	5.03	4.45
H_2O	.33	.83	.42	.92	4.59	1.22	1.21
TiO_2	.15	.25	.32	.10	.20	.45	.10
MnO	Trace.	Trace.	Trace.	Trace.	Trace.	.05	Trace.
Li_2O	Trace.	Trace.	Trace.	Trace.			
	99.65	99.78	99.33	99.82	99.74	99.60	99.62
Sp. gr.	2.61	2.59	2.62	2.61	2.37	2.64	2.60

H. Feldspar porphyry, dike below Castle. *Lassenose.* Contains orthoclase, less plagioclase, hornblende, biotite partly altered to chlorite, sometimes allanite, and occasional iron ore, apatite, and zircon. P. R. C. 555.

I. Rhyolitic tuff, near forks of Checkerboard Creek. Contains fragments of shale, quartz, plagioclase, sanidine, and hornblende, in a brownish material carrying pumiceous glass. Much decomposed, with formation of kaolin. P. R. C. 562.

J. Syenitic mass included in granite, head of Cottonwood Creek. *Akerose.* Contains orthoclase, plagioclase, quartz, hornblende, biotite, apatite, and iron ore. A hornblende-mica syenite. P. R. C. 554.

K. Diorite, between Blackhawk and Robinson. *Andose.* Contains plagioclase, orthoclase, quartz, biotite, diallage, hypersthene, iron ore, apatite, and zircon. P. R. C. 559.

L. Basalt, Volcano Butte. *Kilauose.* Contains labradorite, augite, olivine, a little serpentine, occasional quartz grains, small patches of glass, iron ore, chiefly ilmenite, apatite, a trace of calcite, and a mineral which may be nephelite or analcite. P. R. C. 565.

M. Augite vogesite, dike on west side of upper Fourmile Creek. *Kentallenose.* Contains augite, hornblende, iron ore, a little plagioclase, orthoclase, calcite, and some decomposition products. P. R. C. 563.

N. Monchiquite-like dike rock, west side of upper Willow Creek. *Ourose.* Contains augite, olivine, biotite, ilmenite, and a colorless base which appears to be partially zeolitized glass. Also a little serpentine, chlorite, and calcite. P. R. C. 564.

	H	I	J	K	L	M	N
SiO_2	65.87	61.21	61.87	56.80	46.52	45.15	42.46
Al_2O_3	16.82	15.67	17.26	18.30	10.48	15.39	12.04
Fe_2O_3	1.58	4.06	2.35	1.64	4.40	2.76	3.19
FeO	1.23	.62	2.43	5.58	7.79	5.64	5.34
MgO	1.54	1.58	1.82	3.63	10.58	6.38	12.40
CaO	2.65	2.18	3.23	5.31	9.49	8.83	12.14
Na_2O	4.72	1.57	5.18	4.35	3.12	2.67	1.21
K_2O	3.15	2.75	3.83	3.28	1.55	2.77	2.68
H_2O	1.43	10.20	1.07	.53	1.79	2.85	4.03
TiO_2	.37	.56	.87	.46	2.98	2.80	2.47
P_2O_5	Trace.	....	Trace.	Trace.	.83	.56	.84
X [a]	....	....	....	....	.73	....	....
MnO	Trace.	.10	.03	Trace.	.11	.14	.16
Li_2O	....	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
CO_2	....	....	....	....	Trace.	4.27	.55
	99.36	100.50	99.94	99.88	100.37	100.21	99.51
Sp. gr.	2.62	....	2.67	2.83	2.99	2.70	2.94

[a] Unseparated rare earths or metallic acids, such as columbic, tantalic, etc.

6. HIGHWOOD MOUNTAINS.

Rocks collected by W. H. Weed and L. V. Pirsson, and described in Bull. 237. Analyses A to N, inclusive, made in the laboratory of the Sheffield Scientific School, under the direction of Professor Pirsson.

A. Trachy-andesite, head of North Fork of Willow Creek. *Adamellose.* Contains hornblende, biotite, iron ore, apatite, plagioclase, and orthoclase, with a little kaolin and limonite. E. B. Hurlbut and B. Barnes, analysts. P. R. C. 1492.

B. Tinguaite porphyry, dike 1 mile north of divide in Highwood Gap. *Highwoodose.* Contains abundant phenocrysts of orthoclase and augite in a groundmass of the same minerals; also a little biotite, apatite, and iron ore, and some secondary kaolin. E. B. Hurlbut, analyst. P. R. C. 1493.

C. Sölvsbergite porphyry, dike north end of South Mountain. *Pulaskose.* Contains phenocrysts of alkali feldspar, ægirine-augite, and melanite, in a groundmass of alkali feldspar. Apatite, iron ore, a trace of calcite, and some kaolin are also present. H. W. Foote, analyst. P. R. C. 1494.

D. Gauteite, dike on Aspen Creek. *Monzonose.* Contains alkali-hornblende and alkali-feldspar phenocrysts, in a groundmass of alkali feldspars; also some apatite and iron ore. Rock stained by limonite. H. W. Foote, analyst. P. R. C. 1495.

E. Syenite porphyry, dike at head of Shonkin Creek. *Borolanose.* Contains augite, biotite, iron ore, and orthoclase, in a groundmass of alkali feldspar; also apatite and some kaolin. W. M. Bradley, analyst. P. R. C. 1496.

	A	B	C	D	E
SiO_2	59.24	58.04	57.18	55.23	51.94
Al_2O_3	13.84	17.24	18.54	18.31	15.78
Fe_2O_3	5.46	2.49	3.65	4.90	4.07
FeO	1.36	1.24	1.15	2.06	3.71
MgO	4.79	1.79	.69	1.85	3.48
CaO	5.60	3.50	2.31	3.62	6.04
Na_2O	3.13	3.37	4.48	4.02	3.44
K_2O	4.22	10.06	8.58	6.43	7.69
H_2O	2.02	1.95	2.10	1.84	2.17
TiO_2	.22	.30	.30	.42	.39
P_2O_5	.34	.22	.05	.58	.59
MnO	Trace.	Trace.	Trace.	Trace.	Trace.
SrO	None.	Undet.	Trace.	Trace.	.28
BaO	Trace.	Undet.	.49	.46	.42
SO_3	.08	Trace.	.06	.23	.29
CO_2	None.	....	....	None.	....
Cl	.04	.38	.77	.32	.06
	100.34	100.58	100.35	100.27	99.83
Less O	.01	.09	.17	.08	.02
	100.33	100.49	100.18	100.19	99.81

F. Syenite, top of Palisade Butte. *Borolanose*. Contains augite, iron ore, apatite, alkali feldspar, a little biotite, some limonite in cracks, much natrolite, and possibly other zeolites. H. W. Foote, analyst. P. R. C. 1497.

G. Leucite shonkinite, head of Davis Creek. *Shonkinose*. Contains augite, iron ore, olivine, biotite, apatite, alkali feldspar, leucite, and some zeolites, with traces of limonite and serpentine. E. B. Hurlbut, analyst. P. R. C. 1498.

H. Analcite basalt, dike east side of Highwood Gap. *Monchiquose*. Contains augite, olivine, biotite, iron ore, apatite, and analcite, with some serpentine and a little kaolin. H. W. Foote, analyst. P. R. C. 1499.

I. Leucite basalt, saddle between Highwood and Pinewood peaks. *Shonkinose*. Contains augite, iron ore, leucite, apatite, altered olivine, chlorite, calcite, and zeolites. H. W. Foote, analyst. P. R. C. 1500.

J. Mica basalt, dike on Arrow Peak. *Cascadose*. Phenocrysts of augite, olivine, and biotite, with some leucite, in a groundmass of the same minerals. Also analcite, iron ore, and apatite. H. W. Foote, analyst. P. R. C. 1501.

	F	G	H	I	J
SiO_2	50.11	49.59	47.82	47.98	46.04
Al_2O_3	17.13	14.51	13.56	13.34	12.23
Fe_2O_3	3.73	3.51	4.73	4.09	3.86
FeO	3.28	5.53	4.54	4.24	4.60
MgO	2.47	6.17	7.49	7.01	10.38
CaO	5.09	9.04	8.91	9.32	8.97
Na_2O	3.72	3.52	4.37	3.51	2.42
K_2O	7.47	5.60	3.23	5.00	5.77
H_2O	4.47	1.95	3.37	2.10	2.87
TiO_2	.82	.36	.67	.58	.64
P_2O_5	.67	.15	1.10	1.03	1.14
MnO	Trace.	Trace.	Trace.	Trace.	Trace.
SrO	.35	.21	.21	.14	.25
BaO	.63	.49	.16	.50	.48
SO_3	.08	.02	Trace.	Trace.	Trace.
CO_2	....	....	....	1.24	....
Cl	.07	.13	.04	.21	.11
	100.09	100.78	100.20	100.29	99.76
Less O	.02	.03	.01	.07	.03
	100.07	100.75	100.19	100.22	99.73

K. Missourite, head of Shonkin Creek. *Albanose*. Described in Am. Jour. Sci., 4th ser., vol. 2, p. 315. Contains apatite, iron ore, olivine, biotite, augite, and leucite, the two latter being the chief minerals. Some zeolites and analcite are also present. E. B. Hurlbut, analyst. P. R. C. 356.

L. Fergusite, head of Shonkin Creek. *Fergusose*. Contains augite, olivine, biotite, iron ore, apatite, orthoclase, nephelite, zeolites, and traces of serpentine, limonite, and kaolin. Contains pseudomorphs after leucite. E. B. Hurlbut, analyst. P. R. C. 1502.

M. Monzonite, Highwood Peak. *Shoshonose*. Contains augite, biotite, iron ore, apatite, plagioclase, and alkali feldspar. E. B. Hurlbut, analyst. P. R. C. 1503.

N. Syenite, Middle Peak. *Borolanose*. Contains augite, olivine, biotite, iron ore, apatite, plagioclase, and orthoclase. The two latter, with augite, are the chief minerals. E. B. Hurlbut, analyst. P. R. C. 1504.

	K	L	M	N
SiO_2	46.06	51.75	51.00	52.05
Al_2O_3	10.01	14.52	17.21	15.02
Fe_2O_3	3.17	5.08	2.41	2.65
FeO	5.61	3.58	4.23	5.52
MgO	14.74	4.55	6.19	5.39
CaO	10.55	7.04	9.15	8.14
Na_2O	1.31	2.93	2.88	3.17
K_2O	5.14	7.61	4.93	6.10
H_2O	1.44	2.25	.63	.35
TiO_2	.73	.23	.13	.47
P_2O_5	.21	.18	.33	.21
MnO	Trace.	Trace.	Trace.	Trace.
SrO	.20	.07	.14	.28
BaO	.32	.30	.34	.42
SO_3	.05	Trace.	.03	.02
Cl	.03	.05	Trace.	.24
	99.57	100.14	99.60	100.03
Less O	.01	.01	....	.06
	99.56	100.13	....	99.97

O. White syenite of the Shonkin Sag laccolith. *Borolanose.* Partial analysis. P. R. C. 1505.

P. Shonkinite, Shonkin Sag laccolith. *Montanose.* Contains augite, olivine, biotite, and orthoclase. P. R. C. 1506.

Rocks O, P, described by Weed and Pirsson in Am. Jour. Sci., 4th ser., vol. 12, p. 1. Analyses by W. F. Hillebrand, record No. 1885.

	O	P
SiO_2	50.00	47.88
Al_2O_3	[a] 19.36	12.10
Fe_2O_3	3.87	3.53
FeO	2.67	4.80
MgO	2.18	8.64
CaO	4.96	9.35
Na_2O	3.63	2.94
K_2O	8.52	5.61
H_2O-	.46	.70
H_2O+	[b] 3.53	1.52
TiO_2	....	.77
ZrO_2	....	.03
P_2O_5	....	1.11
Cr_2O_3	....	.035
V_2O_3	....	.04
MnO	....	.15
NiO	....	Trace.
SrO	....	.13
BaO	....	.46
CO_2	None.	.12
S	....	.025
Cl	....	Trace.
F	....	.05
	99.18	99.99

[a] Includes TiO_2 and P_2O_5.

[b] Loss on ignition.

The following rock and separations, from Square Butte, at the east end of the Highwood Mountains, are described by Lindgren in Am. Jour. Sci., 3d ser., vol. 45, p. 286. Analyses by W. H. Melville, record No. 1268.

A. Post-Cretaceous sodalite syenite. *Pulaskose.* Contains orthoclase, some albite, hornblende, sodalite, analcite, and apatite. Orthoclase predominates. The sodalite amounts to 8 per cent. P. R. C. 184 and 201.

B. Hornblende separated from A. Near barkevikite.

C. Sodalite from A. Sp. gr., 2.265.

D. Analcite from A. Sp. gr., 2.255.

In addition, the orthoclase gave 3.88 per cent Na_2O and 11.03 per cent K_2O. A separation of mixed feldspars (sp. gr., 2.56) gave 6.08 per cent Na_2O and 8.91 per cent K_2O.

	A	B	C	D
SiO_2	56.45	38.41	41.56	49.54
Al_2O_3	20.08	17.65	29.48	25.07
Fe_2O_3	1.31	3.75	....	....
FeO	4.39	21.75	.49	.40
MgO	.63	2.54	.15	.20
CaO	2.14	10.52	.49	.22
Na_2O	5.61	2.95	19.21	15.32
K_2O	7.13	1.95	.91	.89
H_2O-	.26	....	.45	Undet.
H_2O+	1.51	.24	3.73	Undet.
TiO_2	.29	....	....	....
P_2O_5	.13	....	....	....
NiO	Trace.	Trace.	....	....
MnO	.09	.15	....	....
Cl	.43	....	4.79	1.67
	100.45	99.91	101.26	93.31
Less O	.10	....	1.08	.38
	100.35	....	100.18	92.93

7. BEARPAW MOUNTAINS.

Described by Weed and Pirsson, Am. Jour. Sci., 4th ser., vol. 1, pp. 283 and 351, and vol. 2, pp. 136 and 188. Analyses by H. N. Stokes, record Nos. 1558 and 1572.

A. Quartz syenite porphyry, Gray Butte. *Nordmarkose.* Contains anorthoclase, microlites of plagioclase, ægirite, augite, quartz, and apatite, with an occasional zircon and very few biotite leaves. P. R. C. 897.

B. Quartz syenite, Beaver Creek stock. *Liparose.* Contains orthoclase, albite, quartz, augite, and iron oxides, with very little biotite, hornblende, and sphene. P. R. C. 900.

C. Basic syenite or monzonite (yogoite), Beaver Creek. *Monzonose.* Contains orthoclase, plagioclase, diopside, biotite, iron oxides, and apatite. P. R. C. 902.

	A	B	C
SiO_2	66.22	68.34	52.81
Al_2O_3	16.22	15.32	15.66
Fe_2O_3	1.98	1.90	3.06
FeO	.16	.84	4.76
MgO	.77	.54	4.99
CaO	1.32	.92	7.57
Na_2O	6.49	5.45	3.60
K_2O	5.76	5.62	4.84
H_2O-	.08	.15	.16
H_2O+	.24	.30	.93
TiO_2	.22	.21	.71
P_2O_5	.10	.13	.75
MnO	Trace.	.07	Trace.
SrO	.06	.04	.09
BaO	.29	.08	.24
Li_2O	Trace.	None.	Trace.
SO_3	.02	Trace.	Trace.
Cl	.04	.04	.07
F	Trace.	None.	Trace.
	99.97	99.95	100.24

D. Shonkinite, Beaver Creek. *SR. 3 of wyomingase.* Contains anorthoclase, diopside, biotite, iron oxides, and apatite, with very little olivine and probably a trace of nephelite. P. R. C. 901.

E. Leucitite, Bearpaw Mountains. *Chotose.* An olivine-free leucite basalt. Contains leucite, augite, iron oxides, rarely biotite, and very little glassy base. P. R. C. 903.

F. Tinguaite, dike on Bear Creek. *Judithose.* Contains orthoclase, nephelite, cancrinite, augite, ægirite, apatite, a little sodalite, and a doubtful fibrous hornblende. P. R. C. 899.

G. Pseudoleucite-sodalite tinguaite. Beaver Creek. *Janeirose.* Contains orthoclase, nephelite, sodalite, nosean, ægirite, diopside, and fluorite. P. R. C. 904.

	D	E	F	G
SiO_2	50.00	46.51	57.46	51.93
Al_2O_3	9.87	11.86	15.40	20.29
Fe_2O_3	3.46	7.59	4.87	3.59
FeO	5.01	4.39	.87	1.20
MgO	11.92	4.73	1.37	.22
CaO	8.31	7.41	2.59	1.65
Na_2O	2.41	2.39	5.48	8.49
K_2O	5.02	8.71	9.44	9.81
H_2O-	.17	1.10	.09	.10
H_2O+	1.16	2.45	.82	.99
TiO_2	.73	.83	.60	.20
P_2O_5	.81	.80	.21	.06
Cr_2O_3	.11	None.		
NiO	.07	.04		
CoO		Trace.		
MnO	Trace.	.22	Trace.	Trace.
CuO		Trace.		
SrO	.07	.16	.16	.07
BaO	.32	.50	.60	.09
Li_2O	Trace.	Trace.	Trace.	Trace.
SO_3	.02	.05	.13	.67
CO_2	.31	None.	.13	.25
Cl	.08	.04	.20	.70
F	.16	Trace.	Trace.	.27
	100.01	99.78	100.42	100.58
Less O	.08	.02	.05	.27
	99.93	99.76	100.37	100.31

8. ELKHORN MINING DISTRICT.

Rocks collected by W. H. Weed. Described in detail by J. S. Barrell in 22d Ann., pt. 2, p. 511. Analysis by H. N. Stokes, record No. 1858.

A. Gabbro, west side of Black Butte. *Hessose.* Contains labradorite, augite, hornblende, biotite, and magnetite, with a little quartz and zircon. P. R. C. 351.

B. Andesite, Elkhorn Mountain. *Harzose.* Contains plagioclase, hornblende, biotite, and pyroxene. P. R. C. 413.

C. Hornblende andesite porphyry, southwestern part of the district. Contains plagioclase and hornblende phenocrysts in a groundmass of hornblende. Pyrite, pyrrhotite, and perhaps magnetite are also present. P. R. C. 412.

D. Quartz monzonite, Elkhorn. *Harzose.* Contains labradorite, orthoclase, quartz, biotite, hornblende, augite, magnetite, apatite, and titanite. P. R. C. 407.

E. Aplite, north of Black Butte, middle of intrusion. *Toscanose-tehamose.* P. R. C. 410.

F. Like E, eastern side of intrusion.

E and F contain soda-orthoclase and quartz, with a little plagioclase and occasional crystals of magnetite and biotite. P. R. C. 411.

	A	B	C	D	E	F
SiO_2	47.44	59.64	54.50	64.31	76.26	74.61
Al_2O_3	18.21	16.64	17.97	15.44	12.94	13.36
Fe_2O_3	5.37	2.33	8.55	2.43	.69	.83
FeO	6.06	4.35		2.58	.13	.36
MgO	5.53	2.10	3.37	2.21	.17	.35
CaO	9.98	4.59	9.36	4.22	1.10	1.35
Na_2O	2.58	3.31	2.34	2.71	2.73	2.49
K_2O	1.17	4.16	1.62	4.09	5.26	5.70
H_2O-	.13	.14	.14	.19	.17	.19
H_2O+	1.08	.69	.96	.79	.43	.42
TiO_2	1.38	1.08	.94	.71	.11	.11
P_2O_5	.68	.49	.31	.22	.06	.06
S	[a].03	[a].01	.63	Trace.	[a].01	Trace.
MnO	.06	Trace.	Trace.	Trace.	Trace.	Trace.
SrO	.08	.05	.05	Trace.	None.	Trace.
BaO	.08	.10	.06	.07	.07	.10
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
	99.85	99.68	100.80	99.97	100.13	99.93

[a] May be present either as S or SO_3.

Cr_2O_3, NiO, CO_2 are all absent.

The following rocks were also analyzed for Weed, who supplies the petrographic data:

G. Grossularite hornfels. Contains diopside, grossularite, calcite, and quartz.

H. Lime-enriched gabbro. Contains labradorite, pyroxene, and scapolite. Analyses G, H, by W. T. Schaller, record No. 2158.

I. Grossularite hornstone, a modified marble. Contains calcite, chlorite, grossularite, and augite.

J. Mica diorite, the normal batholith rock. *Harzose*. Contains labradorite, soda orthoclase, quartz, biotite, hornblende, augite, magnetite, and apatite.

Analyses I, J, by E. C. Sullivan, record No. 2195. In these the TiO_2 and P_2O_5 were not separated from the alumina.

	G	H	I	J
SiO_2	40.31	49.42	36.91	60.84
Al_2O_3	12.11	13.58	6.54	16.36
Fe_2O_3	8.67	3.98	19.43	2.40
FeO	.40	3.59	.67	3.23
MgO	2.65	5.06	1.07	3.85
CaO	33.61	18.15	31.09	4.96
Na_2O	.79	2.22	Trace.	2.90
K_2O	.12	1.42	.18	4.10
H_2O-	.23	.28	.70	.48
H_2O+	.22	.50	1.57	1.03
TiO_2	.78	.71	Undet.	Undet.
CO_2	None.	Undet.	1.91	....
P_2O_5	.69	1.38	Undet.	Undet.
	100.58	100.29	100.07	100.05

9. MARYSVILLE DISTRICT.

Rocks described by Joseph Barrell in P. P. 57. Analyses by George Steiger, record No. 2021.

A. Hornblende microdiorite, near West Belmont mine, east slope of Mount Belmont. *Andose-shoshonose*. Contains feldspars, 60 per cent; hornblende, 35 per cent; and small amounts of quartz, magnetite, biotite, augite, and apatite.

B. Hornblende porphyrite, north slope of the town of Bald Butte. *Andose.* Contains feldspar, largely oligoclase, about 75 per cent; and hornblende, 23 per cent; with secondary hornblende, calcite, and chlorite.

C. Quartz diorite, road up Woodchopper Gulch. *Yellowstonose.* Typical of the Marysville batholith. Contains andesine, 52 per cent; quartz, 31 per cent; orthoclase, 11 per cent; and minor biotite, hornblende, magnetite, titanite, and apatite.

	A	B	C
SiO_2	52.07	56.88	63.55
Al_2O_3	15.99	15.61	16.57
Fe_2O_3	4.77	2.95	2.36
FeO	5.59	2.34	1.98
MgO	4.54	6.35	1.51
CaO	7.50	5.23	4.69
Na_2O	2.97	3.59	3.78
K_2O	2.79	2.39	2.78
H_2O-	.34	.67	.31
H_2O+	1.60	3.03	1.11
TiO_2	1.08	.49	.42
CO_2	None.	None.	.69
P_2O_5	.40	.13	.21
SO_3	....	....	.06
MnO	....	....	.13
BaO	....	....	.15
SrO	....	....	.04
	99.64	99.66	100.36

10. LIVINGSTON QUADRANGLE.

Rocks analyzed for J. P. Iddings, who furnishes the descriptions. Published by W. H. Emmons in Jour. Geology, vol. 16, p. 193. Analyses by G. Steiger, record Nos. 2135, 2147.

A. Granodiorite, 1¼ miles northwest of Haystack Mountain. *Adamellose.* Contains plagioclase, orthoclase, quartz, hornblende, biotite, pyroxene, and magnetite.

B. Orthoclase gabbro, 1 mile northeast of Haystack Mountain. *Shoshonose.* Contains plagioclase, orthoclase, quartz, pyroxene, biotite, magnetite, apatite, and very little altered olivine.

C. Pyroxene separated from B.

D. Olivine gabbro, one-half mile northeast of Haystack Mountain. *Hessose.* Contains olivine, plagioclase, pyroxene, biotite, and magnetite.

	A	B	C	D
SiO_2	65.06	54.09	50.95	47.87
Al_2O_3	14.71	16.00	2.72	16.34
Fe_2O_3	2.82	2.92	1.70	3.59
FeO	1.31	5.54	13.86	7.17
MgO	2.48	5.19	15.58	7.80
CaO	3.43	7.37	11.39	10.33
Na_2O	3.86	3.38	} .31	{ 2.43
K_2O	3.48	2.67		.92
H_2O-	.31	.20	.60	.28
H_2O+	1.10	.77	1.20	1.25
TiO_2	.61	.99	1.42	1.02
CO_2	None.	None.	....	.44
P_2O_5	.18	.35	....	.41
NiO	None.	None.	....	.02
MnO	.18	.15	.26	.14
BaO	.10	.10	....	.03
SrO	.05	.06	....	Undet.
	99.68	99.78	99.99	100.04

S, SO_3 and ZrO_2 absent.

E. Granodiorite porphyry, 1 mile northeast of Haystack Mountain. *Tonalose.* Contains plagioclase, subordinate orthoclase, quartz, biotite, pyroxene, magnetite, and little hornblende.

F. Quartz diorite, north of Haystack Mountain. *Tonalose.* Nearly the same mineral composition as E.

G. Biotite-orthoclase gabbro, north of Haystack Mountain, between Blue and Mud Lakes. *Monzonose.* Contains plagioclase, orthoclase, a little quartz, pyroxene, biotite, magnetite, and apatite.

H. Mica separated from G.

	E	F	G	H
SiO_2	64.09	57.98	54.84	33.07
Al_2O_3	16.20	17.01	16.41	13.00
Fe_2O_3	2.61	3.34	3.63	17.22
FeO	2.40	3.34	4.54	....
MgO	2.06	2.74	4.71	11.33
CaO	4.51	7.35	6.64	2.45
Na_2O	3.88	3.92	3.27	.28
K_2O	2.51	2.02	2.83	6.11
H_2O-	.22	.14	.34	5.41
H_2O+	.44	.49	.93	11.61
TiO_2	.49	.90	.99	....
P_2O_5	.24	.43	.35	....
NiO	None.	Trace.	None.	....
MnO	.09	.12	None.	....
BaO	.15	.06	.12	....
SrO	.03	.02	.05	....
	99.92	99.86	99.65	100.48

CO_2, ZrO_2, S, and SO_3 absent.

11. PHILIPSBURG QUADRANGLE.

Rocks described by Emmons and Calkins in P. P. 78.

A. Biotite granite, Royal mine. *Amiatose.* Contains quartz, plagioclase, orthoclase, and biotite, with accessory muscovite, magnetite, apatite, zircon, titanite, and allanite. P. R. C. 1922.

B. Granodiorite, from head of east fork of Rock Creek. *Lassenose.* Contains quartz, plagioclase, orthoclase, biotite, and a little hornblende, with accessory apatite, zircon, titanite, magnetite, and allanite. P. R. C. 1923.

C. Granodiorite, from a quarry one-half mile southwest of Cable mine. *Tonalose.* Contains plagioclase, orthoclase, quartz, biotite, and hornblende, with accessory magnetite, apatite, and zircon, and secondary chlorite, epidote, calcite, kaolin, muscovite, and titanite. P. R. C. 1925. Analyses A, B, C by G. Steiger, record No. 2367.

D. Pyroxene aplite, about a mile northeast of Rumsey Mountain. *Mariposose.* Contains plagioclase, quartz, orthoclase, pyroxene, titanite, scapolite, apatite, and zircon. P. R. C. 1924.

E. Scapolite-pyroxene aplite, from cliff east of Foster Creek, about one-half mile north of the county boundary. *Shoshonose.* Contains scapolite, plagioclase, quartz, alkali feldspar, pyroxene, hornblende, titanite, apatite, and zircon, with secondary calcite, epidote, and sericite. P. R. C. 1926. Analyses D, E by W. F. Hillebrand, record No. 2365.

F. Cordierite-orthoclase rock, near Cable. Not described in the published report. Analysis by W. T. Schaller, record No. 2496. P. R. C. 1929.

	A	B	C	D	E	F
SiO_2	68.40	70.05	60.19	68.00	57.98	63.47
Al_2O_3	16.34	15.04	17.39	16.33	19.32	17.33
Fe_2O_3	.17	.70	2.04	.26	.44	5.09
FeO	1.56	1.32	4.28	.70	.83	
MgO	.64	1.04	2.10	1.41	1.93	1.32
CaO	3.77	2.46	5.69	5.90	8.87	.64
Na_2O	3.39	4.03	3.30	6.20	3.62	.50
K_2O	3.91	3.33	2.67	.38	4.01	7.09
H_2O-	.29	.70	.31	.06	.57	2.66
H_2O+	.55	1.12	.89	.25	.67	
TiO_2	.29	.36	.85	.43	.66	.96
ZrO_2	None.	.02	.04	.02	.04	....
CO_2	None.	None.	.21	None.	.53	.36
P_2O_5	.22	.08	.30	.22	.17	....
S	None.	None.	None.	.01	.01	....
Cl	....	....	....	.13	.17	....
F	....	....	....	.07	.07	....
MnO	.07	.08	.11	.02	.07	....
SrO	.05	.05	.02	.03	.05	....
BaO	.15	.10	.08	.03	.12	....
Li_2O	....	....	....	None.	Trace.	....
	99.80	100.43	100.47	100.45	100.13	99.42
Less O	....	....	....	.06	.07	....
	....	....	....	100.39	100.06	....

12. RADERSBURG.

Four rocks collected by A. N. Winchell, who furnishes the petrographic data. Analyses by Chase Palmer, record No. 2640.

A. Andesite porphyry, Rena Gold Mining Co. *Tonalose.* Contains plagioclase, hornblende partly altered to magnetite and chlorite, and augite.

B. Same as A, much altered to calcite. Some sulphide of iron present, little quartz and also chlorite.

C. Andesite porphyry, Keating Gold Mining Co. Much altered, with much limonite and hematite. Contains epidote, chlorite, sericite, quartz, kaolinite, and calcite.

D. Same as C, extremely altered. Contains quartz, epidote, sericite, some recrystallized feldspar apparently orthoclase, and a little limonite stain.

	A	B	C	D
SiO_2	56.61	57.35	60.78	63.69
Al_2O_3	17.91	16.33	18.10	18.60
Fe_2O_3	4.22	1.47	3.15	.94
FeO	2.70	2.58	.97	.09
MgO	2.21	4.31	2.04	.18
CaO	6.88	6.12	4.61	.24
Na_2O	3.10	.70	2.81	.32
K_2O	2.71	3.82	2.75	12.81
H_2O-	.29	.62	.68	.51
H_2O+	1.16	3.05	2.62	1.14
TiO_2	.71	.65	.24	.32
CO_2	.13	.70	None.	None.
P_2O_5	.46	.16	.62	.10
SO_3	....	2.43	.16	.30
S	.03	....	....	....
MnO	.58	.30	.39	.34
BaO	.14	.05	.18	.37
	100.84	100.64	100.10	99.95

13. MISCELLANEOUS ROCKS.

A. Granite syenite porphyry, near Antoine Butte, Little Rocky Mountains. *Liparose.* Described by Weed and Pirsson, Jour. Geology, vol. 4, p. 399. Contains orthoclase, quartz, oligoclase, iron oxides, and a little muscovite. Analysis by H. N. Stokes, record No. 1558. P. R. C. 905.

B. Quartz monzonite, near head of Mill Creek, Bitterroot Range. *Toscanose.* Described by Lindgren in P. P. 27. Analysis by W. F. Hillebrand, record No. 1921. Contains quartz, potash feldspar, plagioclase, biotite, apatite, titanite, and magnetite. P. R. C. 1519.

C. Nepheline syenite, 2 miles north of Libby. *Miaskose.* Sp. gr. 2.639. Consists of about equal amounts of nepheline, albite, and microcline, with accessory ægirite, apatite, magnetite, fluorite, cancrinite, and zeolites.

D. Apatite pyroxenite, 2 miles north of Libby. *V. 2. 1. 3. 4.* Sp. gr. 3.417. Consists largely of pyroxene, with notable amounts of biotite and apatite, and a little magnetite, titanite, and perofskite.

Rocks C, D collected by J. T. Pardee, and described by E. S. Larsen. Analyses by G. Steiger, record No. 2707.

	A	B	C	D
SiO_2	68.65	72.07	59.13	37.47
Al_2O_3	18.31	15.51	22.20	2.86
Fe_2O_3	.56	.31	2.04	11.77
FeO	.08	1.01	.33	7.83
MgO	.12	.35	None.	10.12
CaO	1.00	1.93	.58	21.68
Na_2O	4.86	4.02	10.20	.47
K_2O	4.74	4.09	4.35	.93
H_2O-	.27	.03	.37	.27
H_2O+	.83	.30	1.23	.73
TiO_2	.20	.16	.07	1.07
ZrO_2	....	....	.02	None.
CO_2	....	None.	None.	.36
P_2O_5	Trace.	.11	.05	4.33
S	....	....	None.	.04
SO_3	Trace.	....	....	....
Cl	.03	....	....	....
F	Trace.	....	.20	.36
MnO	Trace.	Trace.	.05	.16
SrO	.10	....	None.	.14
BaO	.13	....	None.	.06
V_2O_3	....	....	None.	.12
Li_2O	Trace.	....	....	....
	99.88	99.89	100.82	100.77
Less O	....	....	.08	.25
	....	....	100.74	100.52

IDAHO.

Rocks A to K, inclusive, are described by Waldemar Lindgren in 20th Ann., pt. 3, p. 75.

A. Quartz monzonite, Idaho-Democrat mine, Hailey. *Toscanose.* Contains quartz, orthoclase, microcline, oligoclase, biotite, apatite, titanite, and magnetite. Sp. gr., 2.672, 27.5°. P. R. C. 1916.

B. Same rock and locality as A, but in altered condition. Contains quartz, sericite, chlorite, calcite, pyrite, rutile, etc. Sp. gr., 2.472, 29°. P. R. C. 1917.

C. Diorite, Crœsus mine, Hailey. *Andose.* Contains labradorite, biotite, diallage, hypersthene, hornblende, quartz, titanite, magnetite, orthoclase, and chlorite. Sp. gr., 2.826, 28°. P. R. C. 1918.

D. Same rock and locality as C, but in altered condition. Contains quartz, sericite, chlorite, calcite, pyrite, arsenopyrite, rutile, etc. Sp. gr., 2.898, 28°. P. R. C. 1919.

Analyses A to D by W. F. Hillebrand, record No. 1826. The metals which are bracketed with sulphur represent sulphides. Traces of lithia are present in all four.

	A	B	C	D
SiO_2	68.42	71.93	57.78	58.01
Al_2O_3	15.01	12.21	16.28	15.72
Fe_2O_3	.97	.64	1.02	.64
FeO	1.93	2.99	4.92	3.87
MgO	1.21	.58	4.60	2.07
CaO	2.60	2.59	6.65	2.15
Na_2O	3.23	.23	3.25	.10
K_2O	4.25	3.29	2.22	4.79
H_2O-	.54	.37	.34	.31
H_2O+	.73	2.06	.92	2.71
TiO_2	.50	.40	1.07	1.08
P_2O_5	.13	.10	.30	.31
CoO, NiO	None.	None.	.02	None.
MnO	.06	.18	.15	.17
SrO	.03	None.	.07	None.
BaO	.12	Trace.	.12	Trace?
CO_2	.20	1.96	.15	2.86
S	.02	.18	.02	1.25
Fe	....	.13	....	1.52
Co, Ni	....	None.	....	.12
Zn	....	.09	....	....
Pb	....	Trace.	....	.86
Cu	....	None.	....	.05
As	....	....	....	1.65
	99.95	99.92	99.88	100.24

E. Altered rhyolite, De Lamar mine, Silver City. Contains quartz, sericite, pyrite, apatite, and rutile, with some undeterminable magnesian mineral. Analysis by H. N. Stokes, record No. 1731.

F. Altered rhyolite, De Lamar mine. Contains sericite, quartz, kaolinite, and pyrite. Sp. gr., 2.655, 23°.

G. Altered rhyolite, De Lamar mine. Contains quartz, sericite, kaolinite, and pyrite. Sp. gr., 2.576, 24°.

H. Diabasic basalt, Trade Dollar mine, Silver City. *Camptonose.* Contains labradorite, augite, chlorite, magnetite, secondary quartz, etc.

Analyses F, G, and H by Hillebrand, record No. 1826.

	E	F	G	H
SiO_2	66.69	87.37	78.59	48.47
Al_2O_3	15.40	7.44	12.13	16.07
Fe_2O_3	1.84	.09	None.	4.12
FeO	Undet.	.18	.09	7.47
MgO	.85	.12	.41	5.96
CaO	.09	.10	.16	4.84
Na_2O	.16	.14	.10	2.43
K_2O	3.50	1.79	2.55	1.41
H_2O-	.83	.51	.82	2.30
H_2O+	2.97	1.39	2.47	4.63
TiO_2	2.11	.09	.12	1.51
P_2O_5	.08	Trace.	Trace.	.44
CoO, NiO	....	None.	None.	Trace.
MnO	Trace.	Trace?	Trace?	.23
SrO	....	None.	None.	Trace.
BaO	.09	.02	.02	.03
Li_2O	....	Trace.	Trace.	Trace.
SO_3	.11	....	....	....
FeS_2	3.99	1.00	2.61	.24
Cu	....	....	....	Trace.
	98.71	100.24	100.07	100.15

Heavy metals not looked for in E.

I. Quartz monzonite, Schafer Butte, Boise County. *Lassenose.* Contains quartz, orthoclase, oligoclase, biotite, apatite, titanite, and magnetite. Analysis by George Steiger, record No. 1802. P. R. C. 1520.

J. Granodiorite, Silver Wreath mine, Boise County. *Yellowstonose.* Contains orthoclase, oligoclase, apatite, biotite, titanite, and magnetite. Described in 18th Ann., pt. 3, p. 642. Sp. gr., 2.714, 23°.

K. Same as J, but in altered condition. Also described in 18th Ann. Contains sericite, quartz, titanite, apatite, and pyrite, with carbonates of calcium, magnesium, and iron. Sp. gr., 2.774, 23°.

Analyses J and K by George Steiger, record No. 1691.

L. Volcanic sand, Nez Perces region. Collected by I. C. Russell.

Analysis by W. F. Hillebrand, record No. 1906.

M. Typical basalt, Cinder Buttes, west side of Snake River plains. *Camptonose.* Analysis by W. F. Hillebrand, record No. 1950. Analysis published by Russell in Bull. 199, but the mineralogical composition of the rock is not given. Sp. gr., 2.907 at 24°.

	I	J	K	L	M
SiO_2	69.56	65.23	66.66	68.95	51.14
Al_2O_3	15.29	16.94	14.26	14.33	13.95
Fe_2O_3	.86	1.60	.67	1.17	2.15
FeO	2.06	1.91	2.41	1.23	12.97
MgO	.69	1.31	.95	.47	2.21
CaO	2.81	3.85	3.37	2.13	6.56
Na_2O	3.97	3.57	None.	5.08	3.59
K_2O	3.36	3.02	4.19	2.58	2.33
H_2O-	.86	.18	.36	.28	.12
H_2O+		.88	2.16	3.63	.22
TiO_2	.55	.66	.49	.42	2.41
ZrO_2	....	....	....	.03	.12
CO_2	....	.25	3.67	....	....
P_2O_5	.16	.19	.17	.10	1.59
MnO	....	Trace.	Trace.	Trace.	.44
NiO	....	....	....	....	Trace.
BaO	....	.19	None.	.08	.25
SrO	....	....	....	Trace.	Trace.
Li_2O	....	....	....	Trace.	None.
S	....	None.	.95	Trace.	....
F	....	....	....	?	.10
Cl	....	....	....	....	Trace.
FeS_2	....	....	....	....	.15
V_2O_3	....	....	....	....	Trace.
	100.17	99.78	100.11	100.48	100.30
Less O	....	....	.24	....	....
	....	....	100.07	....	....

N. Quartz monzonite, near Gem. *Pulaskose.* Contains plagioclase, alkali feldspar, hornblende, and quartz, with a little biotite, pyroxene, titanite, and magnetite.

O. Syenite porphyry, near Bradyville. *Monzonose.* Contains microcline, plagioclase, hornblende, pyroxene, apatite, magnetite, and titanite, with secondary epidote, sericite, and green amphibole. P. R. C. 1665.

Rocks N, O, from the Cœur d'Alene district, are described by F. L. Ransome and F. C. Calkins in P. P. 62. Analyses by Steiger, record No. 2194.

P. Granite porphyry. *Toscanose.* Contains orthoclase, a little plagioclase, quartz, and biotite, with accessory titanite and magnetite.

Q. Granite porphyry. *Toscanose.* Like P, but with more plagioclase and noteworthy diopside.

R. Diopside rock in contact with Q. Almost entirely diopside, with a few grains of plagioclase and a little titanite.

Rocks P, Q, R, from the White Knob copper region near Mackay. Received from J. B. Umpleby, who supplies the petrographic data. Analyses by Chase Palmer, record Nos. 2786, 2798.

	N	O	P	Q	R
SiO_2	61.41	58.53	71.26	70.18	51.55
Al_2O_3	17.99	16.85	13.94	12.97	4.00
Fe_2O_3	2.93	3.49	1.01	.82	1.02
FeO	1.39	2.37	1.35	.86	6.65
MgO	1.20	1.46	.67	.95	11.38
CaO	4.75	3.93	1.64	3.98	24.23
Na_2O	4.01	4.05	3.96	2.89	.38
K_2O	4.59	7.12	4.35	5.40	.18
H_2O-	.11	.12	.26	.18	.14
H_2O+	.68	.49	.55	.29	.25
TiO_2	.53	.71	.56	.54	.32
CO_2					None.
P_2O_5	.19	.24	.10	.26	.24
SO_3	.05	.04			
F			Trace?	.035	
MnO	.16	.19	.55	.55	.30
BaO	.11	.10			
SrO	.14	.14			
	100.24	99.83	100.20	99.905	100.64

COLORADO.

1. DENVER BASIN.

Rocks described by Cross in Mon. XXVII. Analyses A, B, D, and E by L. G. Eakins, C by W. F. Hillebrand. All but A were made in the Denver laboratory.

A. Dolerite, dike near Valmont. *Shoshonose.* Contains augite, plagioclase, olivine, orthoclase, and biotite, with accessory magnetite and apatite. Record No. 1145. P. R. C. 534.

B. Augite separated from A. P. R. C. 105.

C. Basalt, Table Mountain, lower capping sheet. *Shoshonose.* Contains plagioclase, orthoclase, augite, magnetite, and apatite, with olivine much serpentinized. Sp. gr., 2.83, 22.5°.

D. Basalt, earlier flow, south slope of North Table Mountain. *Shoshonose.* Contains augite, olivine, plagioclase, probably orthoclase, magnetite, apatite, and a little biotite. P. R. C. 535.

E. Augite-mica syenite, from north fork of Turkey Creek, Jefferson County. *Shoshonose.* Contains orthoclase, augite, biotite, rhombic pyroxene, hornblende, plagioclase, quartz, apatite, and magnetite. Sp. gr., 2.857, 29.5°. P. R. C. 532.

	A	B	C	D	E
SiO_2	48.25	49.10	52.59	49.69	56.90
Al_2O_3	16.73	7.95	17.91	18.06	18.50
Fe_2O_3	3.99		3.81	2.64	.17
FeO	6.28	8.30	5.18	6.19	4.61
MgO	5.77	12.37	4.11	5.73	5.10
CaO	8.32	22.54	7.24	8.24	6.17
Na_2O	3.24	Trace.	2.94	2.99	2.99
K_2O	4.08	Trace.	3.83	3.90	4.14
H_2O	1.72		1.24	.91	.51
TiO_2	.89		.84	.85	.19
P_2O_5	.68		.14	.81	.79
MnO	Trace.		Trace.	.13	Trace.
BaO	.01				
Cl	.08		.05	.13	Trace.
SO_3	.12				
	100.16	100.26	99.88	100.27	100.07

The following rocks from the Denver Basin were analyzed by L. G. Eakins in the Denver laboratory, but the analyses do not appear in the monograph. The subjoined data have been supplied by Whitman Cross.

A. Enstatite diabase porphyry, Mount Morrison *Bandose.* Contains labradorite and enstatite in a groundmass of considerable amount, which is colorless and cryptocrystalline, probably feldspathic, and carries magnetite and other indistinct ferritic matter. P. R. C. 533.

B. Augite andesite, Table Mountain. *I. 5. 3. 3.* Contains plagioclase (andesine), with rare augite and biotite, in a groundmass of plagioclase, augite, magnetite, and minor accessories. This rock contained ptilolite in its vesicular equivalent. Described in Proc. Colorado Sci. Soc., 1886, p. 72.

C. Augite andesite, a pebble from the Denver beds, Table Mountain. *Yellowstonose.* A few augite and andesite phenocrysts in a groundmass of oligoclase, orthoclase, and quartz (?) grains, with some augite and magnetite.

	A	B	C
SiO_2	56.74	59.26	59.29
Al_2O_3	18.80	23.63	21.27
Fe_2O_3	.15	.30	3.33
FeO	6.91	.57	1.04
MgO	5.57	.31	1.12
CaO	7.34	5.93	5.25
Na_2O	2.32	4.94	3.39
K_2O	.77	4.78	3.00
H_2O	1.09	.74	1.63
P_2O_5	.20	....	.23
MnO	.07	....	.21
	99.96	100.46	99.76
Sp. gr	2.876, 27°	2.625, 31°	2.596, 14.5°

2. PIKES PEAK DISTRICT.

GRANITE.

Rocks A to G described by E. B. Mathews. For description of A, C, E, and F see Jour. Geology, vol. 8, p. 214. Analyses by W. F. Hillebrand, record No. 1470.

A. Granitite, Sentinel Point, western part of Pikes Peak massif. *Alaskose.* Contains microcline, microcline-perthite, quartz, biotite, a little oligoclase, and accessory fluorite, apatite, zircon, sphene, magnetite, and allanite. P. R. C. 67 and 600.

B. Granitite, near road between Florissant and Platte River. *Kallerudose.* Consists chiefly of microcline in perthitic intergrowth with albite, quartz, and biotite. P. R. C. 606.

C. Porphyritic granitite, south side of Pikes Peak, ridge between Middle and North Beaver creeks. *Liparose.* Contains microcline, perthite, orthoclase, oligoclase, quartz, biotite, and accessory apatite, fluorite, zircon, and magnetite. P. R. C. 602.

D. Sheared granite, Currant Creek Canyon, north of Twelvemile Park. *Magdeburgose.* Contains perthitic microcline, quartz, muscovite, and sericitic aggregates replacing plagioclase and a part of the microcline. P. R. C. 604.

E. Granite, Currant Creek Canyon, north of Twelvemile Park. *Omeose.* Consists chiefly of perthitic microcline, quartz, greenish biotite, muscovite, and plagioclase altered to a sericitic mass. Also flakes of limonite. Accessory minerals rare. P. R. C. 603.

F. Granitite, Middle Beaver Creek, south side of Pikes Peak. *Liparose.* Contains microcline, orthoclase, perthitic albite, oligoclase, abundant quartz, biotite, and a little accessory magnetite, fluorite, and zircon. P. R. C. 601.

G. Granite gneiss, north of Twin Creek. *Kallerudose.* Contains microcline, orthoclase, quartz, biotite, abundant fluorite, and a little sphene and apatite. P. R. C. 605.

	A	B	C	D	E	F	G
SiO_2	77.03	75.92	75.17	74.40	73.90	73.51	66.90
Al_2O_3	12.00	12.96	12.66	14.43	13.65	13.28	14.86
Fe_2O_3	.76	.33	.23	.89	.28	.94	.93
FeO	.86	1.40	1.40	.22	.42	.97	3.41
MgO	.04	Trace.	.05	.07	.14	.05	.31
CaO	.80	.15	.82	.58	.23	1.11	1.23
Na_2O	3.21	4.60	2.88	1.76	2.53	3.79	5.56
K_2O	4.92	4.15	5.75	6.56	7.99	5.22	5.02
H_2O-	.14	.16	.16	.15	.16	.16	.16
H_2O+	.30	.32	.66	.92	.33	.62	.31
TiO_2	.13	.05	.10	.12	.07	.18	.43
P_2O_5	Trace.	Trace.	.03	.22	.05	Trace.	.12
MnO	Trace.	.04	Trace.	Trace.	Trace.	Trace.	.15
SrO	None.	None.	Trace?	None.	None.	None.	None.
BaO	Trace.	Trace.	.03	Trace.	Trace.	Trace.	.14
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	.06
F	.36	.12	.31	.04	None.	.55	1.00
CO_2	....	.03	....	....	....	....	....
	100.55	100.23	100.25	100.36	99.75	100.38	100.59
Less O	.15	.05	.13	.02	....	.22	.42
	100.40	100.18	100,12	100.34	....	100.16	100.17

The four following rocks, from the Colorado Springs quadrangle, were collected by G. I. Finlay. Descriptions furnished by Cross. Analyses by G. Steiger, record No. 2236.

H. Riebeckite granite, Rosemount. *Grorudose.* Contains quartz and alkali feldspar, with considerable amounts of riebeckite, less barkevikite, and very little zircon, magnetite, and titanite.

I. Aplitic granite, east of St. Peters Dome. *Kallerudose.* Consists chiefly of quartz and alkali feldspar, with small amounts of riebeckite and a mica rich in iron.

J. Micaceous granite, east of Fairview. *Liparose.* Rich in lepidomelane and riebeckite, with quartz and alkali feldspar. Accessory constituents rare, fluorite probably among them.

K. Lamprophyre dike in granite, Bear Creek Canyon. *Ilmenose.* Consists of alkali feldspar, plagioclase, and hornblende, with small amounts of biotite, quartz, muscovite, and other minor accessories.

	H	I	J	K
SiO_2	73.82	77.31	73.22	61.46
Al_2O_3	10.59	12.45	10.93	14.55
Fe_2O_3	2.18	.43	3.94	2.30
FeO	2.98	.33	1.20	5.78
MgO	.04	None.	None.	.50
CaO	.28	.50	.41	2.74
Na_2O	4.20	4.72	3.63	4.71
K_2O	4.57	3.84	4.59	4.88
H_2O-	.39	.42	.87	.54
H_2O+	.49	.40	.99	.74
TiO_2	.13	.06	.22	1.07
ZrO_2	None.	None.	None.	.02
P_2O_5	.02	None.	None.	.27
F	.06	.15	.10	.14
S	None.	None.	None.	.01
MnO	None.	.01	.03	.25
BaO	None.	None.	None.	.17
	99.75	100.62	100.13	100.13
Less O	.02	.06	.04	.06
	99.73	100.56	100.09	100.07

CO_2 and SO_3 absent; SrO not looked for.

ROCKS OF THE CRIPPLE CREEK DISTRICT.

Rocks A to L described by Cross. Descriptions published, except when otherwise stated, in 16th Ann., pt. 2, pp. 38–50. Analyses, with two exceptions, which are properly noted, by W. F. Hillebrand, record Nos. 1448, 1453, and 1524.

A. Phonolite, dike in granite northeast of Big Bull Mountain. *Miaskose.* Contains anorthoclase, nepheline, sodalite, ægirine-augite, some ægirine, biotite, magnetite, and limonite. Nosite not distinguishable. P. R. C. 616.

B. Phonolite, Mitre Peak. *Miaskose.* Contains sanidine, nepheline, sodalite, ægirine, nosite, and colorless particles which may be låvenite. P. R. C. 608.

C. Phonolite, hill 1 mile south of Straub Mountain. *Miaskose.* Contains anorthoclase, sanidine, nepheline, sodalite, nosite, analcite, and ægirine, with sometimes ægirine-augite. P. R. C. 612.

D. Phonolite, Rhyolite Mountain. *Miaskose.* Contains nepheline, nosite, analcite, ægirine, and some ægirine-augite, in a feldspathic groundmass. Sp. gr., 2.52, 23°. P. R. C. 618.

E. Phonolite, between Florissant and Manitou. *Miaskose.* Analysis by L. G. Eakins, made in the Denver laboratory, inserted here for comparison with the Cripple Creek samples. Described by Cross in Proc. Colorado Sci. Soc., vol. 2, p. 167. Contains sanidine, nepheline, hornblende, with accessory pyroxene (?), magnetite, apatite, and sphene. Sp. gr., 2.576, 13°. P. R. C. 607.

F. The portion of E soluble in hydrochloric acid. This portion amounted to 25.39 per cent, and is recalculated here to 100. Analysis by Eakins.

	A	B	C	D	E	F
SiO_2	59.00	58.98	58.78	58.64	60.02	44.66
Al_2O_3	20.07	20.54	20.03	19.62	20.98	31.59
Fe_2O_3	1.58	1.65	1.87	2.17	2.21	.95
FeO	.65	.48	.49	.42	.51	....
MgO	.10	.11	.16	.37	Trace.	....
CaO	1.05	.67	.83	1.24	1.18	2.25
Na_2O	8.34	9.95	9.36	8.39	8.83	18.42
K_2O	5.63	5.31	5.50	5.26	5.72	2.13
H_2O-	.24	.19	.31	.34	.70	
H_2O+	2.03	.97	1.57	2.40		....
TiO_2	.29	.24	.29	.20	....	....
P_2O_5	.05	.04	.03	.03	Trace.	....
ZrO_2	.20	.20	.17	.09	....	....
MnO	.12	.26	.15	.20	Trace.	....
SrO	None.	None.	None.	Trace.	....	....
BaO	Trace.	None.	None.	Trace.	....	....
Li_2O	Trace.	Trace.	Trace.	Trace.	....	....
SO_3	.07	.20	.12	Trace?	....	....
Cl	.24	.28	.58	.14	Trace.	....
CO_2	.26	....	....	.23	....	....
	99.92	100.07	100.24	99.74	100.15	100.00

G. Trachytic phonolite, dike on west slope of Bull Cliff. (The latite-phonolite of Graton.) *Miaskose.* Contains alkali feldspars, nepheline, nosite, sodalite, augite, scanty ægirine, brown hornblende, magnetite, sphene, apatite, and sometimes låvenite. P. R. C. 624.

H. Altered phonolite, Washington shaft, Victor. Contains potash feldspars, with some alteration to muscovite. Crystals of pyrite and fluorite are visible, but nepheline and ægirine have disappeared. P. R. C. 623.

I. Nepheline syenite, near the Longfellow mine. *Akerose.* Contains alkali feldspars, nepheline, sodalite, augite, some ægirine, hornblende, biotite, sphene, apatite, and magnetite. Sp. gr., 2.68, 23°. P. R. C. 626.

J. Nepheline basalt, Appie Ellen shaft. Much altered. Rich in olivine, augite, and magnetite. Also contains nepheline, feldspars in small amount, and biotite. Sp. gr., 2.99, 23°.

K. Altered nepheline basalt, Anna Lee mine.

L. Local facies of a phonolitic mass, Bull Cliff. *Akerose.* Contains abundant augite, plagioclase, alkali feldspar, magnetite, and a little red-brown biotite, with a colorless isotropic base in the darker spots. P. R. C. 627.

	G	H	I	J	K	L
SiO_2	59.38	56.74	54.34	35.03	48.61	49.84
Al_2O_3	19.47	20.30	19.21	9.80	20.74	17.78
Fe_2O_3	1.60	1.06	3.19	5.55	4.29	5.86
FeO	1.19		2.11	4.98	.22	2.62
MgO	.36	.23	1.28	9.78	2.11	3.02
CaO	1.96	.57	4.53	15.09	.25	7.35
Na_2O	7.80	.62	6.38	2.04	.16	5.20
K_2O	5.83	13.36	5.14	2.16	.77	3.04
H_2O-	.11	.33	.14	.41	12.10	.34
H_2O+	.69	1.15	1.17	2.05	7.07	2.02
TiO_2	.58	.58	1.09	2.20	3.57	1.43
P_2O_5	.08	.25	.27	1.99	.29	.76
ZrO_2	.10	.07	.07	None.		.03
Cr_2O_3					Trace.	
V_2O_3			.02			.03
MnO	.15	None.	.08	.06	None.	.21
SrO	.03	Trace.	.16	.17	None.	.18
BaO	.13	.19	.24	.14	None.	.22
Li_2O	Trace.	Trace.	Trace.	Trace.	(?)	Trace.
SO_3	.37		.07	None.		None.
Cl	.22		.28	Trace.		Trace.
F		Undet.	Undet.	Undet.	.63	Undet.
CO_2			None.	7.83		.52
FeS_2		4.65		.38		
	100.05	100.10	99.77	99.66	100.81	100.45

The following Cripple Creek rocks, M to Y, are described in P. P. 54, mainly by L. C. Graton.

M. Granite, Ajax mine. Contains microcline, oligoclase, quartz, biotite, and apatite.

N. Altered granite adjacent to M. Contains quartz, potash feldspar, fluorite, and pyrite. Described as an ore. Descriptions of M and N furnished by F. L. Ransome.

O. Biotite trachyte, Portland mine. *Phlegrose.*

P. Syenite, Portland mine. *Monzonose.* Contains pyroxene, plagioclase, orthoclase, hornblende, apatite, magnetite, and titanite.

Q. Latite-phonolite, Portland mine. *Essexose.* Contains pyroxene, plagioclase, orthoclase, hornblende, analcite, nosean, sodalite, apatite, magnetite, and titanite.

R. Latite-phonolite, 3,300 feet 10° east of south from Bull Cliff. *Essexose.* Contains pyroxene, plagioclase, orthoclase, hornblende, nosean, analcite, apatite, magnetite, titanite, sodalite, and secondary zeolites. Analyses M to R by W. F. Hillebrand, record No. 2132. All contain traces of lithia.

	M	N	O	P	Q	R
SiO_2	66.20	59.58	62.79	51.89	54.88	54.43
Al_2O_3	14.33	16.00	19.10	17.94	18.53	19.01
Fe_2O_3	2.09	.30	2.29	3.85	2.93	2.85
FeO	1.93	.65	.36	3.37	1.92	1.93
MgO	.89	.03	.40	2.88	1.26	.99
CaO	1.39	2.03	.87	5.62	4.15	4.33
Na_2O	2.58	.98	6.23	4.63	6.65	6.92
K_2O	7.31	11.93	5.58	4.50	4.90	5.07
H_2O-	.48	.32	.25	.72	.33	.31
H_2O+	.83	.81	.84	2.09	1.75	1.68
TiO_2	.65	.75	.71	1.34	.93	.96
ZrO_2	.02	(?)	.02	.03	.03	.04
CO_2	.36	.26	Trace.	Trace.	.13	.14
P_2O_5	.25	.32	.12	.67	.27	.25
SO_3	None.	None.	None.	None.	.36	.42
Cl	Trace.	(?)	Trace.	Trace.	.14	.22
F	(?)	.69	(?)	(?)	(?)	(?)
MoO_3		.01				
FeS_2	.12	4.78	.10	.41	.10	.07
MnO	.13	Trace.	.07	.03	.25	.08
BaO	.18	.11	.14	.19	.18	.21
SrO	Trace.	.01	.03	.11	.11	.21
V_2O_3		.39				
	99.74	99.95	99.90	100.32	99.85	100.12
Less O		.29			.03	
		99.66			99.82	

S. Latite-phonolite, Portland mine. *Akerose.* Contains pyroxene, plagioclase, orthoclase, magnetite, apatite, and very little sodalite.

T. Latite-phonolite, Anaconda mine. *Akerose.* Contains pyroxene, plagioclase, orthoclase, magnetite, apatite, titanite, hornblende, sodalite, analcite, and a little biotite. Analyses S, T by G. Steiger, record No. 2152.

U. Trachydolerite, Isabella dike. *Akerose.* Contains plagioclase, pyroxene, olivine, orthoclase, analcite, apatite, magnetite, biotite, and hornblende.

V. Vogesite, Jennie Sample mine. *Monzonose.* Contains orthoclase, hornblende, pyroxene, biotite, plagioclase, brown mica, iron ores, rare apatite, some analcite, and often olivine.

W. Monchiquite, Block 8 mine. *Ourose.* Contains pyroxene, olivine, analcite, biotite, apatite, magnetite, and alteration products. Analyses S to W by W. T. Schaller, record No. 2171.

X. Granitic gneiss. Contains albite, orthoclase, quartz, and biotite.

Y. Mica schist. Contains quartz, sillimanite, muscovite, and magnetite. Descriptions of X and Y supplied by W. Lindgren. Analyses by Schaller, record No. 2163.

	S	T	U	V	W	X	Y
SiO_2	56.01	58.05	48.76	47.31	44.08	56.69	51.88
Al_2O_3	17.92	17.66	17.04	16.21	12.80	17.00	23.86
Fe_2O_3	4.22	3.51	5.04	5.11	4.58	5.60	7.24
FeO	2.52	1.65	3.52	2.90	3.84	2.98	1.89
MgO	2.04	1.55	4.57	3.08	7.22	2.88	1.43
CaO	4.80	4.48	8.64	7.11	11.21	4.50	.21
Na_2O	4.92	5.80	4.27	3.92	2.97	3.37	.68
K_2O	4.21	4.06	3.39	3.73	3.31	3.48	5.55
H_2O-	.31	.35	.69	.87	.77	[a]1.65	[a]6.05
H_2O+	1.10	.87	1.84	2.17	2.35		
TiO_2	1.20	.91	1.34	1.64	1.43	.81	.76
ZrO_2	.02	.02	Trace.	.01	None.		
CO_2	None.	None.	.22	4.98	4.14		
P_2O_5	.55	.40	.79	.90	.70	.44	.07
S	.02		.06	.06	.14		
SO_3	None.	.04	Trace.	.05	.01		
Cl	Trace.	Trace.	.01	.05	.04		
MnO	.13	.13	.08	Trace.	.14		
BaO	.16	.19	.15	.17	.13		
SrO	.06	.08	.07	.02	.06		
Cr_2O_3	None.	None.	Trace?	Trace?	.05		
Li_2O			Trace.	Trace.	Trace.		
	100.19	99.75	100.48	100.29	99.97	99.40	99.62

[a] Loss on ignition.

MISCELLANEOUS ROCKS.

Analyses, elsewhere unpublished, except when otherwise stated, by W. F. Hillebrand, record Nos. 1448, 1453, and 1669. Petrographic data supplied by Whitman Cross. Names marked with a query are provisional designations only.

A. Rhyolite, near Robbins's ranch. *Toscanose.* Has scattered phenocrysts of alkali feldspar, oligoclase, and biotite in a predominant trachytic groundmass of alkali feldspar, tridymite, particles of residual glass, and ferritic flakes and grains. P. R. C. 1326.

B. Trachyte (?), Wicher Mountain. *Toscanose.* Shows biotite and a few glassy feldspars in a groundmass resembling that of A. P. R. C. 1328.

C. Quartz latite, Bare Hills. *Pulaskose.* Composed mainly of plagioclase and alkali feldspar, with small augites and much ferritic matter. Minute prisms of a yellowish-brown amphibole (?) and scales of tridymite are also visible. P. R. C. 1327.

D. Pyroxene latite, Wicher Mountain. *Monzonose.* Contains phenocrysts of plagioclase, a few of augite, minute specks of iddingsite, and flakes of limonite. In the groundmass are plagioclase, orthoclase (?), augite, iddingsite, and hypersthene. In the pores tridymite appears. P. R. C. 1325.

E. Plagioclase basalt, mesa east of Mac Gulch. *Andose.* Contains plagioclase, augite, olivine, iddingsite, magnetite, biotite, and apatite. P. R. C. 1324.

F. Plagioclase basalt, Saddle Mountain. *Andose.* Phenocrysts of augite and olivine in a groundmass of plagioclase, orthoclase, augite, magnetite, biotite, and apatite. Very fresh. See Cross, Jour. Geology, vol. 5, p. 684. P. R. C. 1323.

	A	B	C	D	E	F
SiO_2	69.52	66.12	62.64	57.48	52.97	48.76
Al_2O_3	15.44	17.21	17.82	18.02	18.31	15.89
Fe_2O_3	1.90	2.43	3.91	5.73	1.86	6.04
FeO	.09	Trace.	.31	.73	6.73	4.56
MgO	.17	.35	.47	1.17	3.04	5.98
CaO	1.70	2.11	3.22	5.03	6.51	8.15
Na_2O	4.54	4.70	4.47	4.28	3.74	3.43
K_2O	5.04	5.57	4.99	4.15	3.35	2.93
H_2O-	.33	.14	.58	.62	.44	.40
H_2O+	.27	.71	.65	.55	.31	1.48
TiO_2	.23	.29	.59	1.00	1.04	1.65
P_2O_5	.14	.11	.25	.66	.81	.60
ZrO_2	.05	.06	.08	.04	.05	None.
V_2O_3	....	....	....	.02	....	....
MnO	.08	.08	.04	Trace.	.09	.13
SrO	.04	.05	.07	.12	.14	.06
BaO	.19	.25	.28	.20	.18	.17
SO_3	....	....	....	.16	....	....
CO_2	.17	....	....	....	....	....
	99.90	100.18	100.37	99.96	99.57	100.23

G. Analcite basalt, from the Basin. *Monchiquose.* Contains phenocrysts of augite, olivine, and analcite. Also magnetite, with subordinate amounts of alkali feldspars, biotite, and apatite. P. R. C. 1322.

H. Portion of the analcite basalt soluble in hydrochloric acid.

I. Augite separated from G.

J. Analcite separated from G. After deduction of 4.22 per cent of substance insoluble in boiling dilute hydrochloric acid, and later removal of liberated silica with weak potash solution. Sixty-two one-hundredths per cent of the water goes off over sulphuric acid. A trace of lithia was found.

The analcite basalt and its fractions are described by Cross in Jour. Geology, vol. 5, p. 684.

	G	H	I	J
SiO_2	45.59	44.44	49.26	51.24
Al_2O_3	12.98	[a] 20.11	6.01	24.00
Fe_2O_3	4.97	7.50	13.31	1.20
FeO	4.70		4.23	
MgO	8.36	5.81	2.40	.33
CaO	11.09	3.94	21.79	1.62
Na_2O	4.53	8.17	.79	11.61
K_2O	1.04	1.13	.41	1.25
H_2O-	.51	7.91	Undet.	9.09
H_2O+	3.40		Undet.	
TiO_2	1.32	....	1.53	....
P_2O_5	.91	....	....	....
ZrO_2	.03	....	....	....
MnO	.14	Trace.	Undet.	....
SrO	.12	.16	.06	.06
BaO	.13	(?)	(?)	....
Cl	.05	.10	....	Trace.
	99.87	99.27	99.79	100.40

[a] Includes P_2O_5 and possible ZrO_2 and TiO_2.

3. APISHAPA QUADRANGLE.

Rocks received from Whitman Cross, who supplies the petrographic data. Analyses by G. Steiger. Record No. 2678.

A. Minette dike, 5 miles west of mouth of Apishapa Canyon. *Jumillose.* Contains biotite, alkali-feldspar, augite, apatite, and hydrous ferritic stains, with a little secondary calcite and chlorite. P. R. C. 1854.

B. Olivine-bearing augite vogesite. *Monchiquose.* Dike, southeast edge of mesa 11 miles south-southeast from Dripping Spring. Contains augite, olivine, biotite, titaniferous magnetite, apatite, alkali-feldspar, and a little calcite. P. R. C. 1852.

C. Hornblende-augite vogesite. *Kentallenose.* Dike, 4 miles west of head of Apishapa Canyon. Contains augite, hornblende, biotite, magnetite, apatite, alkali-feldspar, and plagioclase, with secondary calcite and analcite. P. R. C. 1853.

D. Olivine-plagioclase basalt. *Limburgose.* Dike, 8 miles east-northeast from North Rattlesnake Butte. Contains olivine, augite, magnetite, apatite, biotite, plagioclase rich in soda, and a little chlorite, calcite, and analcite. P. R. C. 1851.

	A	B	C	D
SiO_2	32.32	44.31	43.49	44.64
Al_2O_3	8.16	14.10	12.76	12.82
Fe_2O_3	9.46	4.75	5.92	3.64
FeO	4.10	6.02	5.18	8.34
MgO	5.97	7.80	9.23	10.05
CaO	12.60	9.66	10.54	10.09
Na_2O	.69	3.74	2.40	3.39
K_2O	5.97	2.83	2.53	1.76
H_2O-	1.03	.88	1.86	.36
H_2O+	4.09	3.29	3.05	1.20
TiO_2	4.55	2.10	2.10	1.99
CO_2	6.30	None.	.25	Trace.
P_2O_5	3.78	.53	.75	.90
S	.26	.10	.11	None.
MnO	.13	.18	.10	.16
BaO	.36	.10	.13	.14
SrO	.24	.10	.12	.09
	100.01	100.49	100.52	99.57
Less O	.13	.05	.06	....
	99.88	100.45	100.46	....

4. SILVER CLIFF AND ROSITA.

Rocks described by Cross, mostly in 17th Ann., pt. 2, p. 263. Also, partly in Proc. Colorado Sci. Soc., vol. 2, p. 228. Analyses, with one exception, by L. G. Eakins. Those with record numbers attached were made in the Washington laboratory; all others in the laboratory at Denver.

A. Peridotite, Cottonwood Gulch. *Custerose.* Contains hornblende, biotite, hypersthene, olivine, a little plagioclase, apatite, pyrrhotite, and sillimanite (?). P. R. C. 519.

B. Augite diorite, Mount Fairview, Rosita Hills. *Salemose.* Contains augite, biotite, labradorite, and accessory orthoclase, olivine, magnetite, and apatite. Sp. gr., 2.870, 32°. Olivine a subordinate constituent. P. R. C. 526.

C. The same as B, but with orthoclase in much larger amount. *Akerose.* Sp. gr., 2.768, 34°. Record No. 1091. P. R. C. 529.

D. Trachyte, Game Ridge. *Phlegrose.* Contains sanidine, plagioclase, a little biotite, magnetite, apatite, and zircon in a groundmass of orthoclase, with a little quartz. Sp. gr., 2.592, 29°. P. R. C. 70 and 524.

E. Trachyte, dark-colored dike. *Pulaskose.* Contains more magnetite than D, but otherwise the two are practically identical. Sp. gr., 2.621, 24°. P. R. C. 589.

	A	B	C	D	E
SiO_2	46.03	50.47	53.80	66.03	65.41
Al_2O_3	9.27	18.73	20.13	18.49	18.78
Fe_2O_3	2.72	4.19	3.57	2.18	.94
FeO	9.94	4.92	2.63	.22	.72
MgO	25.04	3.48	2.26	.39	.16
CaO	3.53	8.82	5.60	.96	1.58
Na_2O	1.48	4.62	5.20	5.22	5.91
K_2O	.87	3.56	4.49	5.86	5.41
H_2O	.64	.58	.90	.85	1.38
TiO_2	....	.51	.43	....	....
P_2O_5	.17	.10	.56	.04	Trace.
MnO	.40	.11	.29	Trace.	Trace.
CO_2	....	Trace.	....	Trace.	....
Cl	....	Trace.	....	....	....
	100.09	100.09	99.86	100.24	100.29

F. Andesite, Pringle Hill. *Pulaskose.* Contains plagioclase, orthoclase, quartz, biotite, augite, magnetite, and apatite, with sometimes a little hornblende. Sp. gr., 2.651, 17.8°. Record No. 1124. P. R. C. 528.

G. Pringle andesite, dike. *Laurvikose.* Like F, but often contains sphene. Sp. gr., 2.690, 28°. P. R. C. 527.

H. Bunker andesite, Lookout Mountain. *Akerose.* Contains plagioclase, orthoclase, augite, biotite, hornblende, quartz, magnetite, and apatite. Sp. gr., 2.699, 34°. Record No. 1091.

I. Altered Bunker andesite, Robinson Plateau. *Toscanose.* Biotite gone, magnetite altered to limonite, feldspar not much attacked. Record No. 1124. Sp. gr., 2.580, 19.7°.

J. Much-decomposed Bunker andesite, ridge near Knickerbocker Hill. *Liparose.* Augite, hornblende, and biotite all replaced by decomposition products, plagioclase much muscovitized. Record No. 1124. P. R. C. 592.

	F	G	H	I	J
SiO_2	58.94	63.49	57.01	63.88	67.13
Al_2O_3	17.19	18.40	18.41	19.96	18.41
Fe_2O_3	2.63	2.44	3.69	2.21	.45
FeO	1.98	1.09	2.36	.57	.07
MgO	1.52	.66	2.34	.58	.44
CaO	4.45	2.30	4.29	2.03	.55
Na_2O	4.20	5.70	4.95	4.19	4.17
K_2O	3.90	4.62	3.72	3.88	5.28
H_2O	4.53	1.04	2.29	2.63	2.98
TiO_2	.27	Trace.	.27	....	.30
P_2O_5	.23	Trace.	.42	....	Trace.
MnO	.10	.16	.21	Trace.	Trace.
CO_2	....	Trace.	....	....	....
	99.94	99.90	99.96	99.93	99.78

K. Dacite, Bald Mountain, near Rosita. *Lassenose.* Contains plagioclase, biotite, hornblende, sometimes augite, magnetite, and quartz. Sp. gr., 2.574, 24°. Record No. 1068. P. R. C. 530.

L. Mica dacite. *Lassenose.* Contains plagioclase, sanidine, biotite, and quartz. Sp. gr., 2.563, 24°. Record No. 1068.

M. Rhyolite, Pennsylvania Hill. *Toscanose.* Sp. gr., 2.470, 26°. Record No. 1079. P. R. C. 525.

N. Rhyolite, Round Mountain. *Omeose.* Contains sanidine, quartz, some glass, and accessory garnet. P. R. C. 521.

O. Rhyolite, Silver Cliff. *Magdeburgose.* Sp. gr., 2.560, 15°. Record No. 1125. P. R. C. 522.

	K	L	M	N	O
SiO_2	66.46	67.49	70.87	75.20	75.39
Al_2O_3	17.91	17.76	15.18	12.96	13.65
Fe_2O_3	2.42	2.54	2.18	.37	.38
FeO	.35	.08	.12	.27	.18
MgO	.49	.35	.60	.12	.15
CaO	2.89	1.67	1.58	.29	.51
Na_2O	4.79	5.03	3.47	2.02	1.84
K_2O	3.74	4.40	5.04	8.38	6.81
H_2O	1.01	.52	1.08	.58	1.13
TiO_2			Trace.		Trace.
P_2O_5		Trace.	Trace.	Trace.	Trace.
MnO	Trace.	Trace.	Trace.	.03	.14
	100.06	99.84	100.12	100.22	100.18

P. Rhyolitic tuff, a lake-bed deposit east of the Blue Mountains. Mainly composed of glassy rhyolite dust.

Q. Devitrified pitchstone, the gangue of ptilolite, 3 miles southeast of Silver Cliff. *Riesenose.* Shows feldspar, quartz, and barite. Described by Cross and Eakins in Am. Jour. Sci., 3d ser., vol. 44, p. 96. Record No. 1342. P. R. C. 590.

R. Pitchstone, Rosita. *Alaskose.* Record No. 1033. P. R. C. 531.

S. Pitchstone, Fleetwood Tunnel, Silver Cliff. *Liparose.* P. R. C. 523.

T. Alteration product of S. Consists mainly of silica and kaolin. Record No. of S and T 1034. P. R. C. 591.

U. Decomposition product of pitchstone, Silver Cliff. Analysis by W. F. Hillebrand.

	P	Q	R	S	T	U
SiO_2	71.02	65.67	73.11	71.56	71.71	84.77
Al_2O_3	14.27	13.48	13.16	13.10	12.36	8.46
Fe_2O_3	1.22	1.51	.62	.66	1.10	.52
FeO			.23	.28		
MgO	Trace.	.31	.19	.14	1.21	.92
CaO	1.38	2.41	.54	.74	1.11	1.18
Na_2O	2.28	1.52	2.85	3.77	.17	
K_2O	3.97	2.42	5.10	4.06	.36	
H_2O	6.12	12.27	4.05	5.52	11.97	4.11
P_2O_5		Trace.				
MnO		Trace.	.14	.16	.17	
BaO		.32				
SO_3		.28				
	100.26	100.19	99.99	99.99	100.16	99.96

V. Syenite, Silver Cliff. *Monzonose.* Contains orthoclase and plagioclase in nearly equal amounts, colored by ferric hydroxide, with amphibole, a little biotite, and secondary epidote, calcite, and chlorite. Sp. gr., 2.689, 20°. P. R. C. 71 and 520.

W. Quartz-alunite rock, Democrat Hill. About two-thirds quartz and one-third alunite. Record No. 1126. P. R. C. 596.

X. The same, Mount Robinson. About one-fourth alunite. Record No. 1248. P. C. R. 593.

Y. Quartz-diaspore rock, Mount Robinson. About 18 per cent diaspore, the rest quartz. Record No. 1167. P. R. C. 594.

Rocks W, X, and Y are also described in Am. Jour. Sci., 3d ser., vol. 41, p. 471. These three rocks are decomposition products of rhyolite.

	V	W	X	Y
SiO_2	59.78	65.94	69.67	76.22
Al_2O_3	16.86	12.95	13.72	19.45
Fe_2O_3	3.08	.33		Trace.
FeO	3.72	.07		
MgO	.69	.05	Trace.	
CaO	2.96	.10	.07	Trace.
Na_2O	5.39	1.19	.34	Trace.
K_2O	5.01	2.32	2.44	Trace.
H_2O	1.58	4.47	4.73	3.82
TiO_2				.11
P_2O_5				.13
MnO	.14	Trace.		
BaO		Trace.		
SO_3		12.47	9.27	.29
CO_2	.75			
	99.96	99.89	100.24	100.02

The following analyses, all by L. G. Eakins, do not appear in the published memoir just cited. A and B were made in the Denver laboratory. The petrographic details have been supplied by Whitman Cross.

A. Spherulite in rhyolite, ridge west of Mount Tyndall. Mainly composed of quartz and feldspar needles, with some ferritic coloring due to decomposition of trichites. P. R. C. 1077.

B. Rhyolitic residual glass, same locality as A. P. R. C. 1077.

C. Interspherulitic mass, Rosita. Record No. 1285.

D. Spherulite, Rosita. Record No. 1286.

E, F, G. Spherulites, Silver Cliff. Record Nos. 1285, 1286.

H. Spherulite of rhyolite, Fleetwood Tunnel, Silver Cliff. Sp. gr., 2.389, 20°. P. R. C. 1075.

The spherulites D, E, F, and G are made up of orthoclase needles, with free silica in fibers or grains, or rarely as tridymite. The "soluble silica" is that which is dissolved by sodium carbonate solution.

	A	B	C	D	E	F	G	H
SiO_2	71.27	85.50	74.47	80.61	83.91	79.21	78.77	78.74
Al_2O_3	16.02	7.42	13.87	10.94	9.54	12.24	12.46	12.01
Fe_2O_3	1.41	1.23						Trace.
FeO	.17	.34						
MgO	Trace.	.82	Trace.	.09	Trace.	.11	.09	.09
CaO	.35	.37	.51	.26	.19	.43	.34	.16
Na_2O	5.76	.74	2.10	2.90	.62	2.58	2.12	2.21
K_2O	4.08	2.64	7.46	3.02	5.06	5.26	5.84	5.84
H_2O	1.14	1.22	1.88	2.20	.69	.66	.70	.92
P_2O_5	Trace.	None.						
MnO	Trace.	.08						.13
	100.20	100.36	100.29	100.02	100.01	100.49	100.32	100.10
Soluble SiO_2			12.72	11.12	1.06	1.27	1.25	

5. CENTRAL CITY QUADRANGLE.

Rocks collected by E. S. Bastin, who supplies the petrographic data.

A. Typical schist, 1 mile south of Black Hawk. Analysis by G. Steiger, record No. 2435.

Rocks B to G are from Caribou, and represent a well-defined transition series. Analyses by Steiger, No. 2650, 2657.

B. Quartz monzonite. *Shoshonose.* Contains orthoclase, plagioclase, augite, and biotite, with subordinate magnetite, ilmenite (?), apatite, and quartz.

C. Monzonite. *Shoshonose.* Contains orthoclase, plagioclase, augite, and biotite, with subordinate magnetite, apatite, and quartz.

D. Gabbro. *III. 5. 4. 3.* Contains plagioclase, augite, and biotite, minor apatite, magnetite, pyrite, titanite, and quartz, with secondary hornblende, epidote, calcite, chlorite, and sericite.

E. Hornblendite. *IV. 2. 3. 2. 3.* Contains hornblende, with subordinate biotite, apatite, magnetite, and titanite.

F. Magnetite-rich gabbro. Contains augite, plagioclase, biotite, magnetite, and apatite.

G. Magnetite-pyroxenite. *V. 3. 3. 2. 2.* Contains augite, olivine partly altered to serpentine, and magnetite.

	A	B	C	D	E	F	G
SiO_2	64.23	56.64	53.95	44.26	36.77	30.47	27.71
Al_2O_3	16.45	17.00	18.56	13.95	10.29	9.04	2.92
Fe_2O_3	2.40	3.11	3.86	7.84	10.54	16.37	21.80
FeO	4.31	5.06	4.23	8.87	12.11	14.91	15.70
MgO	1.68	2.79	2.35	6.59	9.34	7.86	17.98
CaO	3.11	6.20	6.58	10.41	12.26	9.33	6.83
Na_2O	3.75	3.16	3.36	1.81	1.16	.77	.19
K_2O	2.14	3.40	3.88	1.75	1.38	2.89	None.
H_2O-	.02	.31	.30	.33	.36	.32	.54
H_2O+	.89	.70	.68	1.54	1.70	1.32	3.51
TiO_2	.80	.81	.76	1.41	2.49	2.52	2.69
CO_2	....	None.	.85	.33	.18	.21	.22
P_2O_5	.10	.44	.60	.85	1.40	2.87	None.
S	.03	.03	.06	.13	.33	.69	.04
CoO	....	....	....	....	.03	.03	.05
MnO	.08	.20	.17	.19	.23	.39	.22
BaO	.02	.06	.13	.03	.04	.09	Trace.
SrO	Trace.	Trace.	.07	.03	.02	.04	Trace.
	100.01	99.91	100.39	100.32	100.63	100.12	100.40
Less O	.01	.01	.03	.06	.16	.35	.02
	100.00	99.90	100.36	100.26	100.47	99.77	100.38

8. IDAHO SPRINGS.

Rocks described by S. H. Ball in P. P. 63.

A. Alkali syenite porphyry, south side of Clear Creek near Soda Creek. *Laurvikose.* Contains anorthoclase, orthoclase, ægirine-augite, garnet, titanite, biotite, apatite, magnetite, and often zircon. Analysis by G. Steiger, record No. 2258.

B. Bostonite porphyry, Red Lyon lode. *Liparose.* Contains plagioclase, anorthoclase, orthoclase, quartz, magnetite, apatite, and zircon.

C. Biotite latite, Chicago Creek. Contains orthoclase, biotite, plagioclase, hornblende, magnetite, apatite, and zircon.

Analyses B, C, by W. T. Schaller, record No. 2263.

	A	B	C
SiO_2	60.30	67.41	66.44
Al_2O_3	18.12	16.23	14.98
Fe_2O_3	2.45	.85	1.57
FeO	1.25	1.14	.43
MgO	.28	.15	.18
CaO	3.89	.14	2.47
Na_2O	5.83	3.95	1.12
K_2O	5.01	7.19	3.32
H_2O-	.75	.67	4.60
H_2O+	.71	.88	4.06
TiO_2	.55	.16	.20
ZrO_2	.01	.11	.01
CO_2	None.	.56	.67
P_2O_5	.25	.05	.11
S	....	Trace.	.02
SO_3	.06	....	....
Cl	....	None.	Trace.
MnO	.12	.16	.13
BaO	.26	Trace.	.11
SrO	....	None.	None.
	99.84	99.65	100.42

7. BRECKENRIDGE.

Rocks described by F. L. Ransome in P. P. 75.

A. Quartz monzonite porphyry, Brewery Hill. *Amiatose near toscanose.* Contains plagioclase, orthoclase, quartz, biotite, magnetite, pyrite, apatite, titanite, zircon, and allanite, with very little calcite and chlorite. P. R. C. 1817.

B. Quartz monzonite porphyry, Browns Gulch. *Toscanose.* Contains orthoclase, plagioclase, quartz, biotite, apatite, rarely allanite, and secondary epidote, calcite, chlorite, and pyrite. P. R. C. 1818.

C. Quartz monzonite porphyry, Mount Guyot. *Amiatose near yellowstonose.* Contains labradorite, orthoclase, quartz, biotite, hornblende, titanite, and magnetite. P. R. C. 1823.

D. Altered quartz monzonite porphyry, Jessie mine. Contains quartz, sericite, and sulphides. Sp. gr. 2.70. P. R. C. 1822.

Analyses A to D by R. C. Wells, record Nos. 2426, 2466.

	A	B	C	D
SiO_2	67.53	68.14	64.28	69.61
Al_2O_3	15.46	15.29	16.99	15.12
Fe_2O_3	2.24	1.36	2.59	.37
FeO	2.42	1.66	2.64	
MgO	.16	.26	1.13	Trace.
CaO	3.24	3.03	3.95	.05
Na_2O	3.24	3.59	3.78	.42
K_2O	3.86	4.07	3.51	4.54
H_2O-	.23	.40	.07	.27
H_2O+	.55	.39	.25	2.01
TiO_2	.41	.36	.49	.36
ZrO_2	.02	.01	.01	.02
CO_2	.03	.22	None.	None.
P_2O_5	.01	.17	.32	.04
F	.03	None.	.06	....
S	.05	.81	None.	....
V_2O_3	....	....	.03	....
Cr_2O_3	None.	....	....	....
NiO	None.	.01	None.	Trace.
MnO	.10	.12	.14	.14
BaO	.07	.03	.10	None.
SrO	None.	.03	.04	None.
CuS	....	....	....	.17
PbS	....	....	....	.06
ZnS	....	....	....	.08
FeS_2	....	....	....	6.92
	99.65	99.95	100.38	100.18
Less O	.03	.29	.03	....
	99.62	99.66	100.35	....

E. Diorite porphyry, Wellington mine. *Akerose.* Contains hornblende, plagioclase, augite or diopside, hypersthene, biotite, magnetite, apatite, and zircon. P. R. C. 1816.

F. Diorite porphyry, Wellington mine. *Akerose.* Contains hornblende, biotite, magnetite, diopside, orthoclase, quartz, magnetite, and apatite. P. R. C. 1821.

G. Altered diorite porphyry, Wellington mine, 10 feet from vein. P. R. C. 1820.

H. Altered diorite porphyry, Wellington mine, close to vein. P. R. C. 1819. Contains carbonates (siderite or dolomite), sulphides, apatite, sericite, and quartz.

Analyses E to H by W. T. Schaller, record No. 2438.

	E	F	G	H
SiO_2	55.44	57.35	49.59	46.62
Al_2O_3	14.95	16.29	14.91	12.66
Fe_2O_3	4.37	3.15	.52	Trace.
FeO	5.18	4.36	10.46	[a] 11.15
MgO	3.58	2.41	2.02	4.02
CaO	6.12	5.66	1.96	1.53
Na_2O	4.44	4.50	1.33	1.35
K_2O	2.83	3.39	3.51	1.68
H_2O-	.12	.15	.16	.31
H_2O+	.84	.70	3.17	3.41
TiO_2	1.22	1.07	1.03	1.01
ZrO_2	None.	Trace.	None.	None.
CO_2	.35	.46	9.40	11.48
P_2O_5	.49	.70	.47	.50
V_2O_3	....	Trace.	....	....
MnO	.22	.12	1.10	.92
BaO	.16	.10	.07	None.
SrO	.04	.05	Trace.	None.
FeS_2	.09	.09	.36	1.99
ZnS	....	None.	Trace.	.97
PbS	....	....	Trace.	.52
	100.44	100.55	100.06	100.12

[a] Doubtful, because of sulphides.

3. TENMILE DISTRICT.

Rocks described by Cross in 14th Ann., p. 165. Analyses made in the Denver laboratory—A and C by W. F. Hillebrand, B by L. G. Eakins.

A. Quartz-hornblende-mica porphyrite, Gold Hill. *Yellowstonose.* Contains plagioclase, hornblende, biotite, and quartz, in a groundmass of quartz, orthoclase, and a little plagioclase. P. R. C. 510.

B. Quartz porphyrite, Sugar Loaf. *Toscanose.* Contains plagioclase, biotite, and quartz, in a groundmass of quartz and orthoclase. P. R. C. 509.

C. Quartz porphyrite, Chicago Mountain. *Lassenose.* Contains plagioclase, orthoclase, biotite, and quartz. P. R. C. 508.

	A	B	C
SiO_2	63.66	67.29	68.30
Al_2O_3	17.05	15.78	16.24
Fe_2O_3	1.97	1.86	1.60
FeO	2.62	1.97	1.63
MgO	1.99	.72	1.05
CaO	3.89	2.36	2.79
Na_2O	4.13	3.77	3.90
K_2O	3.09	3.55	3.52
H_2O- H_2O+	1.19	2.10	.71
TiO_2	Undet.	None.	Undet.
P_2O_5	.27	.28	.13
MnO	.14	.21	.12
SrO	.08	None.	.04
BaO	....	....	Trace.
Li_2O	None.	Trace.	Trace.
CO_2	....	.27	....
	100.08	100.16	100.03

The following rocks were also analyzed in the Denver laboratory. Petrographic data furnished by Whitman Cross.

A. Granite porphyry, McNulty Gulch. *Toscanose.* Contains phenocrysts of orthoclase, oligoclase, andesine, quartz, biotite, and altered hornblende, in a groundmass of quartz, orthoclase, and magnetite. Accessory sphene, allanite, apatite, and zircon, and a little secondary chlorite are also present. Analysis by W. F. Hillebrand. P. R. C. 586.

B. Granite porphyry, Jefferson Tunnel. *Toscanose.* Contains orthoclase, oligoclase, quartz, and biotite, in a groundmass of mainly quartz and orthoclase; also accessory magnetite, apatite, zircon, and allanite. Chlorite appears as a decomposition product of biotite, and calcite and magnetite are present in small amounts. Analyses by Hillebrand.

C. Same as B. *Toscanose.* Analysis by L. G. Eakins. P. R. C. 583.

D. Diorite porphyry, Copper Mountain. *Yellowstonose.* Contains oligoclase, hornblende, and biotite, in a groundmass of quartz, orthoclase, plagioclase, and magnetite; also accessory zircon, sphene, and apatite, and a little secondary chlorite and epidote. Analysis by Eakins. P. R. C. 585.

E. Diorite porphyry, McNulty type. *Lassenose.* Contains oligoclase, andesine, hornblende, biotite, and magnetite, in a groundmass of orthoclase, plagioclase, quartz, magnetite, apatite, allanite, and sphene; also secondary chlorite, epidote, and calcite. Analysis by Eakins. P. R. C. 584.

	A	B	C	D	E
SiO_2	68.60	65.94	65.51	67.01	63.02
Al_2O_3	16.21	16.00	17.01	18.03	17.61
Fe_2O_3	1.67	.60	None.	.66	1.78
FeO	1.57	1.74	2.79	.72	2.76
MgO	1.05	1.02	.90	.84	1.63
CaO	2.61	2.87	3.16	3.99	3.30
Na_2O	3.29	3.85	3.82	4.42	4.72
K_2O	3.88	4.56	4.67	3.53	3.23
H_2O	.92	1.13	1.78	.91	2.03
P_2O_5	.21	.23	.13	.10	.16
MnO	.09	.14		.09	Trace.
SrO	Trace.	Trace.			
BaO				.10	.08
CO_2	.19	1.55			
Cl	.03	.03	Trace.		
S			.38		
FeS		.60			
	100.32	100.26	100.15	100.40	100.32
Specific gravity	2.640, 27°	2.672, 21°	2.666, 26°		2.689, 16.5°

9. LEADVILLE REGION.

Rocks A to G described by Cross in Mon. XII, Appendix A. Analyses made in the Denver laboratory.

A. Mount Zion porphyry, Prospect Mountain. *Toscanose.* Contains orthoclase, plagioclase, quartz, biotite, apatite, magnetite, and zircon. Analysis by L. G. Eakins. P. R. C. 504.

B. White or Leadville porphyry. *Riesenose.* Contains orthoclase, plagioclase, quartz, muscovite, magnetite, apatite, and zircon, with crystals which appear to be rutile and anatase. Sp. gr., 2.680, 16°. Analysis by W. F. Hillebrand. P. R. C. 587.

C. Porphyry, summit of Mount Lincoln. *Lassenose.* Contains quartz, orthoclase, plagioclase, biotite, apatite, sphene, magnetite, zircon, and allanite. The sample analyzed showed some muscovite, chlorite, and calcite. Sp. gr., 2.670, 16°. Analysis by W. F. Hillebrand. P. R. C. 505.

	A	B	C
SiO_2	73.50	70.74	66.45
Al_2O_3	14.87	14.68	15.84
Fe_2O_3	.95	.69	2.59
FeO	.42	.58	1.43
MgO	.29	.28	1.21
CaO	2.14	4.12	2.90
Na_2O	3.46	2.29	3.92
K_2O	3.56	2.59	2.89
H_2O	.90	2.09	.84
TiO_2			.10
P_2O_5	None.		.36
MnO	.03	.06	.09
SrO	Trace.	Trace.	.07
BaO		.03	
Li_2O			Trace.
CO_2		2.14	1.35
Cl		Trace.	.06
	100.12	100.29	100.09

D. Gray porphyry, Johnson Gulch, near Leadville. *Yellowstonose*. Slightly altered. Contains orthoclase, plagioclase, biotite, and quartz, with decomposition products probably derived from original hornblende. Sp. gr., 2.736, 16°. Analysis by Hillebrand.

E. Pink orthoclase crystals from D. Analysis by Hillebrand.

F. Hornblendic porphyrite, lower Buckskin Gulch. *Andose*. Contains plagioclase, orthoclase, quartz, hornblende, biotite, magnetite, apatite, and zircon, with a little secondary calcite and chlorite. Sp. gr., 2.768, 16°. Analysis by Hillebrand. P. R. C. 89 and 506.

G. Biotite porphyrite, dike in gneiss in the North Mosquito amphitheater. *Tonalose*. Composition like F. but with no hornblende, much biotite, and some pyrite. Sp. gr., 2.740, 16°. Analysis by Hillebrand. P. R. C. 507.

	D	E	F	G
SiO_2	68.10	62.22	56.62	64.81
Al_2O_3	14.97	20.33	16.74	15.73
Fe_2O_3	2.78		4.94	1.68
FeO	1.10		3.27	2.91
MgO	1.10		4.08	2.82
CaO	3.04	2.95	7.39	4.22
Na_2O	3.46	3.45	3.50	3.98
K_2O	2.93	8.31	1.97	1.43
H_2O	1.28	1.90	.92	.62
TiO_2	.07			.08
P_2O_5	.16		Trace.	.23
MnO	.09		.15	.08
SrO	.08		Trace.	Trace.
CO_2	.92		1.15	1.08
Cl	.03			.04
FeS_2				.90
	100.11	99.16	100.73	100.61

H. Rhyolite (nevadite), from Chalk Mountain. *Liparose*. Mainly quartz and feldspar, the latter being sanidine and plagioclase. A little biotite, magnetite, apatite, and zircon are present. Analysis by Hillebrand. P. R. C. 64, 512, and 1289.

I. Sanidine from H. Analysis by Hillebrand. P. R. C. 64.

	H	I
SiO_2	74.45	65.04
Al_2O_3	14.72	20.40
Fe_2O_3	None.	....
FeO	.56	....
MgO	.37	....
CaO	.83	.79
Na_2O	3.97	4.11
K_2O	4.53	9.74
H_2O	.66	.29
P_2O_5	.01	....
MnO	.28	....
Li_2O	Trace.	....
	100.38	100.37

The following rock and its separations are described by Cross in Bull. 1. Analyses by W. F. Hillebrand in the Denver laboratory.

J. Hypersthene andesite, Buffalo Peaks. *Andose.* Contains hypersthene, augite, plagioclase, apatite, and magnetite. Sp. gr. 2.742, 16°. P. R. C. 86 and 588.

K, L, M. Hypersthene separated from the rock.

Sp. gr., of M, 3.307, 23°. In K and L alkalies were not tested for. In L and M all the iron is given as FeO.

	J	K	L	M
SiO_2	56.19	51.70	51.16	50.04
Al_2O_3	16.12	1.72	2.15	2.91
Fe_2O_3	4.92	.30	....	....
FeO	4.43	18.00	18.36	17.81
MgO	4.60	25.09	24.25	21.74
CaO	7.00	2.87	3.81	6.70
Na_2O	2.96	....	....	.27
K_2O	2.37	....	....	....
H_2O	1.03	....	....	....
P_2O_5	.27	....	....	....
MnO	Trace.	.36	.36	.12
SrO	Trace.	....	....	....
BaO	Trace.	....	....	....
Cl	.02	....	....	....
	99.91	100.04	100.10	99.59

The following rocks were received from J. D. Irving. No description furnished.

N. Volcanic breccia, South Evans Gulch.

O. Gray porphyry. *Omeose.*

P. Pyritic white porphyry.

Q. Serpentine-magnetite rock.

Analyses N and O by Chase Palmer, record No. 2673. P and Q by R. C. Wells, No. 2677.

	N	O	P	Q
SiO_2	57.19	68.91	66.37	19.01
Al_2O_3	17.12	14.27	11.15	20.32
Fe_2O_3	.76	.90	None.	13.71
FeO	3.15	.23	.32	9.90
MgO	1.69	.67	Trace.	24.35
CaO	4.32	.60	.18	.03
Na_2O	.57	1.96	.56	.42
K_2O	3.22	7.15	9.03	.09
H_2O-	1.57	.43	.14	.43
H_2O+	4.06	1.12	.44	5.88
TiO_2	.53	.41	.23	.18
ZrO_2	....	....	.02	None.
CO_2	4.94	.26	None.	1.85
P_2O_5	.13	.16	None.	.14
S	.28	....	....	....
SO_3	....	....	.35	....
MnO	.17	.02	....	.02
BaO	.27	.08	.10	....
FeS_2	....	3.32	10.75	4.17
	99.97	100.49	99.64	100.50

10. ELK MOUNTAINS.

Analyses made by L. G. Eakins in the Denver laboratory. Petrographic data supplied by Whitman Cross.

A. Rhyolite, East Mountain, Crested Butte district. *Alsbachose.* Phenocrysts of orthoclase, oligoclase, quartz, and biotite, in a microspherulitic and cryptocrystalline groundmass. P. R. C. 514.

B. Rhyolite, Round Mountain, Crested Butte district. *Toscanose.* Small phenocrysts of quartz, sanidine, biotite, and oligoclase, in a groundmass of quartz and orthoclase. P. R. C. 513.

C. Diorite, Brush Creek, Gunnison County. *Tonalose.* Contains several varieties of plagioclase, with orthoclase, quartz, hornblende, biotite, augite, sphene, apatite, and magnetite. P. R. C. 93.

	A	B	C
SiO_2	74.84	71.56	62.71
Al_2O_3	14.05	14.91	17.06
Fe_2O_3	.17	1.47	3.79
FeO	.31	1.04	2.74
MgO	Trace.	.08	1.78
CaO	1.57	1.98	5.51
Na_2O	3.66	3.78	3.54
K_2O	3.14	4.94	2.96
H_2O	2.33	.44	.24
P_2O_5	....	Trace.	None.
MnO	....	....	Trace.
	100.07	100.20	100.33
Sp. gr.	2.38, 17°	2.59, 18°	2.791, 30°

11. WEST ELK MOUNTAINS.

Rocks described by Cross in 14th Ann., p. 165.

A. Hornblende-mica porphyrite, Cliff Creek. *Adamellose.* Contains plagioclase, hornblende, and biotite, in a groundmass of quartz, feldspar, and mica. Analysis by W. F. Hillebrand, record No. 1429.

B. Porphyrite, Storm Ridge. *Yellowstonose.* Contains plagioclase, biotite, hypersthene, hornblende, and augite, in a groundmass of quartz and orthoclase. Analysis by L. G. Eakins, record No. 1238. P. R. C. 517.

C. Porphyrite-diorite, Mount Marcellina. *Yellowstonose.* Contains plagioclase, hornblende, and a little biotite, in a groundmass of quartz and orthoclase. Analysis by T. M. Chatard, record No. 1238. P. R. C. 516.

D. Quartz porphyrite, Mount Carbon. *Amiatose.* Contains plagioclase, orthoclase, biotite, hornblende, augite, and quartz. Analysis by Chatard, record No. 1238. P. R. C. 518.

E. Quartz porphyrite, Crested Butte. *Lassenose.* Contains plagioclase, orthoclase, hornblende, biotite, quartz, and a little augite. Analysis made by Eakins in the Denver laboratory. P. R. C. 515.

	A	B	C	D	E
SiO_2	63.05	61.42	62.85	65.36	65.71
Al_2O_3	15.58	17.69	16.21	15.48	18.30
Fe_2O_3	2.92	4.24	3.08	3.09	1.19
FeO	2.11	1.74	1.46	1.21	1.53
MgO	1.70	1.81	1.47	1.53	.98
CaO	4.15	5.29	4.72	4.14	2.17
Na_2O	3.77	3.14	3.49	3.58	5.00
K_2O	3.66	3.19	3.10	3.41	3.95
H_2O-	.55	.97	.29	.82	1.39
H_2O+	1.38		2.03	.70	
TiO_2	.60	.37	.41	.52	Undet.
P_2O_5	.27	.14	.48	.25	....
MnO	.12	.19	.15	.19	.02
SrO	.07	....	....	....	....
BaO	.13	.09	.11	.08	....
Li_2O	Trace.	....	....	....	....
	100.06	100.28	99.85	100.36	100.24

12. CREEDE.

Rocks received from W. H. Emmons, but no description furnished.

A. Alboroto rhyolite, Solomon mine. *Lebachose.*

B. The same, largely altered to chlorite.

C. Alboroto rhyolite. *Omeose.*

D. Lower rhyolite, Bachelor mine. *Magdeburgose.*

E. "Gouge," from vein in Last Chance mine. Analysis by R. C. Wells, No. 2679.

Analyses A to D by W. C. Wheeler, record No. 2816.

	A	B	C	D	E
SiO_2	73.53	55.25	76.26	77.36	67.06
Al_2O_3	12.87	12.10	11.30	11.37	11.69
Fe_2O_3	.88	1.28	.52	.31	2.11
FeO	.64	10.71	.34	.36	.25
MgO	.56	9.30	.02	.14	Trace.
CaO	.07	.34	.23	.30	.33
Na_2O	.63	.28	2.81	1.38	.45
K_2O	8.92	.39	6.77	7.28	.81
H_2O-	.40	1.49	.39	.55	2.37
H_2O+	.70	6.70	.14	.26	5.52
TiO_2	.19	.15	.15	.16	.09
CO_2	.23	.11	.19	.06	....
P_2O_5	Trace.	Trace.	.01	.03	.71
S	.02	.11	.26	.33	....
SO_3	....	....	....	....	3.23
MnO	.09	1.43	.05	.03	Trace.
BaO	.05	Trace.	.49	.05	....
PbO	....	....	....	....	5.42
	99.78	99.64	99.93	99.97	100.04

13. UNCOMPAHGRE QUADRANGLE.

Rocks collected by E. S. Larsen. Analyses by G. Steiger, record Nos. 2618, 2797, 2824.

A. Latite, Cannibal Plateau. *Andose-akerose.* Carries phenocrysts of olivine, with a few of quartz and augite, in a groundmass of andesine, alkali feldspar, augite, titaniferous magnetite, and apatite.

B. Latite, Cannibal Plateau. *Akerose.* Carries phenocrysts of plagioclase and augite, in a groundmass of alkali feldspar, iron ore, pyroxene, and apatite.

C. Cancrinite syenite, between Deldorado and Beaver Creeks. *Laurvikose.* Largely microperthite, with noteworthy cancrinite, and accessory biotite, ægirite, apatite, titanite, and iron ore.

D. Nepheline gabbro, dike on upper Deldorado Creek. *Hessose.* Contains bytownite, augite, nepheline and olivine, with a little apatite, iron ore, and secondary zeolites.

	A	B	C	D
SiO_2	54.72	56.83	56.74	47.94
Al_2O_3	16.60	16.90	19.32	22.56
Fe_2O_3	3.81	6.85	2.37	2.02
FeO	4.11	.13	1.65	4.77
MgO	2.88	2.67	.27	2.08
CaO	6.31	4.92	1.98	12.08
Na_2O	4.04	4.58	8.05	4.02
K_2O	3.49	4.00	5.88	.84
H_2O-	.68	.38	.32	.24
H_2O+	.49	.40	1.12	1.30
TiO_2	1.52	1.41	.40	1.12
ZrO_2	None.	None.	.02	.02
CO_2	None.	None.	1.50	.16
P_2O_5	.77	.50	.03	.25
S	None.	None.	.05	.03
SO_3	None.	None.	.12	....
F	....	....	....	.14
MnO	.09	.11	.07	.11
BaO	.12	.12	.16	.39
SrO	.05	.06	.12	.31
Cr_2O_3	.01	Trace.	....	....
	99.69	99.86	100.17	100.38

E. Pyroxenite, east of Cebolla Creek and Cebolla Hot Springs. *V. 2. 1. 3. 2* (*3*). Chiefly diopside, with some apatite, magnetite, perofskite, and biotite.

F. Melilite rock, Beaver Creek. *IV. 2. 4* (*3*). *1. 4. 2*. Largely giant crystals of melilite, inclosing diopside, magnetite, perofskite, apatite, biotite, and a little calcite.

G. Ijolite, North Beaver Creek. *Covose*. Contains about equal amounts of nepheline and diopside, with some apatite, magnetite, perofskite, and phlogopite.

H. Perofskite-magnetite rock. *V. 2. 4. 4. 2*. Contains about equal amounts of perofskite, magnetite, and biotite, with less apatite, and perhaps a little ilmenite.

	E	F	G	H
SiO_2	40.25	38.57	38.89	8.43
Al_2O_3	2.74	5.79	12.69	.74
Fe_2O_3	10.83	5.41	7.46	19.16
FeO	7.38	3.33	2.96	13.68
MgO	12.04	8.44	5.01	5.06
CaO	20.21	30.72	18.65	19.98
Na_2O	.42	2.34	4.90	.35
K_2O	None.	.42	2.19	.59
H_2O-	.46	.34	.36	.35
H_2O+	.46	.62	.70	.65
TiO_2	4.76	1.71	2.45	24.74
ZrO_2	None.	.02	.02	.01
CO_2	.07	1.28	.66	None.
P_2O_5	.45	.83	1.78	5.58
S	.02	.03	.60	.04
SO_3	....	....	.25	None.
Cl	Trace?	None.	....	None.
F	None.	None.	....	.19
V_2O_3	.04	....	....	.20
NiO	None.	....	....	.05
MnO	.16	.16	.16	.26
BaO	.03	.28	None.	.05
SrO	Trace?	.35	None.	.12
	100.32	100.64	99.73	100.23

14. LAKE CITY QUADRANGLE.

Rocks collected by Whitman Cross.

A. Pyroxene-hornblende andesite, Falls Creek. *Amiatose*. Consists chiefly of plagioclase, augite, hypersthene, and hornblende, with little magnetite, and apatite, and an abundant glass base. Analysis by G. Steiger, record No. 2244.

B. Decomposed andesite, Slumgullion mud flow. Analysis by W. T. Schaller, record No. 2368.

C. Quartz latite, Nellie Creek. Roadside, a little below main forks of creek. Analysis by R. C. Wells, record No. 2469. *Toscanose*. Carries phenocrysts of plagioclase, biotite, augite, and serpentinized hypersthene, with accessory iron ore and apatite and secondary calcite, in a groundmass of intergrown quartz and orthoclase.

	A	B	C
SiO_2	63.03	56.36	61.85
Al_2O_3	15.86	11.51	16.22
Fe_2O_3	3.31	5.82	5.07
FeO	1.74	1.18	.69
MgO	1.69	1.42	1.50
CaO	4.40	.44	3.60
Na_2O	3.17	.54	3.87
K_2O	3.75	1.30	4.14
H_2O-	.43	8.32	.66
H_2O+	1.73	9.80	.78
TiO_2	.64	.87	.68
ZrO_2	None.	None.	.02
CO_2	....	....	.03
P_2O_5	.24	.35	.15
S	....	....	.21
SO_3	None.	2.50	....
MnO	.10	.08	.08
BaO	.08	.04	.09
SrO	.03	....	.04
	100.20	100.53	99.68

15. OURAY QUADRANGLE.

Rocks described by Ernest Howe in Folio 153. Analyses by G. Steiger, record No. 2200.

A. Quartz-biotite latite, near head of Middle Fork of Cimarron Creek. *Harzose.* Contains plagioclase, a little orthoclase, biotite, augite, accessory magnetite, and very little doubtful quartz.

B. Quartz-biotite latite, north end of Cow Creek instrusive body, between Wildhorse Creek and the West Fork of Cow Creek. *Toscanose.* Contains plagioclase, very little orthoclase, quartz, biotite, and magnetite.

C. Quartz-pyroxene latite, west side of ridge between the Middle and East Cimarron creeks. *Tonalose.* Contains andesine, hornblende, pyroxene, biotite, and magnetite.

D. Quartz monzonite porphyry, Porphyry Basin, Middle Cimarron Creek. *Lassenose.* Contains plagioclase, orthoclase, biotite, hornblende, and magnetite.

	A	B	C	D
SiO_2	59.83	68.81	60.69	61.36
Al_2O_3	15.86	15.54	15.90	16.36
Fe_2O_3	4.07	1.78	4.52	3.59
FeO	2.12	.80	1.72	1.45
MgO	2.73	.52	1.93	1.75
CaO	4.34	2.43	5.23	3.59
Na_2O	3.00	4.24	3.55	4.04
K_2O	3.55	4.07	3.22	3.64
H_2O-	1.09	.50	.93	1.34
H_2O+	2.04	.78	.96	1.56
TiO_2	.70	.28	.73	.51
ZrO_2	None.	Trace.	Trace.	Trace.
CO_2	.50	.48	.27	.64
P_2O_5	.31	.18	.31	.36
NiO	None.	(?)	None.	None.
MnO	.06	.12	.13	.07
BaO	.08	.13	.10	.12
SrO	.02	.04	.03	.12
	100.39	100.65	100.22	100.50

S and SO_3 absent.

16. SILVERTON QUADRANGLE.

Rocks A, B, C, D described by Whitman Cross in Folio 120. Analyses by W. F. Hillebrand, record Nos. 2024, 2042, 2045.

A. Quartz latite, ridge north of Pole Creek. *Amiatose near yellowstonose.* Contains phenocrysts of andesine, hornblende, and a little biotite, in a predominant groundmass of orthoclase, plagioclase, quartz, and a little augite, biotite, and magnetite. P. R. C. 1353.

B. Quartz latite, bench south of Greenhalgh Mountain. *Toscanose.* Contains phenocrysts of oligoclase-andesine and biotite in a groundmass of orthoclase, quartz, and rare accessories. P. R. C. 1354.

C. Pyroxene andesite, ridge west from Edith Mountain. *Tonalose.* Contains phenocrysts of labradorite, augite, hypersthene, biotite, and magnetite, in a groundmass which is largely glass, with feldspar microlites and ferritic particles. P. R. C. 1355.

D. Pyroxene andesite, Dolly Varden mine, Henson Creek. *Harzose.* Contains phenocrysts of labradorite, hypersthene, augite, and magnetite, in a groundmass of plagioclase, orthoclase, quartz, augite, magnetite, etc. P. R. C. 1356.

E. Quartz monzonite, Sultan Mountain, near Silverton. *Amiatose.* Contains plagioclase, orthoclase, quartz, augite, biotite, magnetite, and apatite. Some chlorite and epidote as alteration products. Analysis by L. G. Eakins in the Denver laboratory. Sp. gr., 2.751, 14°. Described by Cross in 21st Ann., pt. 2. P. R. C. 204.

	A	B	C	D	E
SiO_2	62.09	64.93	58.88	56.03	63.91
Al_2O_3	16.77	16.79	15.93	15.97	17.07
Fe_2O_3	3.96	3.54	3.12	4.78	4.39
FeO	.99	.32	2.94	3.00	1.51
MgO	1.63	.65	2.30	3.36	.81
CaO	4.26	2.11	6.05	6.44	4.47
Na_2O	3.77	3.33	3.17	2.85	3.48
K_2O	3.68	4.76	1.86	3.29	3.74
H_2O-	.50	1.12	1.66	1.31	.33
H_2O+	1.32	1.65	2.48	1.08	
TiO_2	.73	.53	.73	1.01	....
ZrO_2	Trace.	.03	.02	Trace?	....
P_2O_5	.25	.17	.34	.48	....
MnO	.14	Trace.	.16	.16	.21
BaO	.10	.15	.12	.08	....
SrO	.05	Trace.	.14	.04	....
Li_2O	Trace.	Trace.	Trace.	....	....
S	None.	Trace?	....	None.	....
FeS_2	....	....	.07	....	....
	100.24	100.08	99.97	99.88	99.92

Rocks F to J described by F. L. Ransome in Bull. 182.

F. Altered andesitic breccia, White Cloud mine. Contains quartz, kaolin, pyrite, rutile, and some undeterminable minerals. Analysis by George Steiger, record No. 1886.

G. Latite, country rock, Polar Star mine, Engineer Mountain *SR. 3 of vaalase.* Contains labradorite, orthoclase (?), quartz, diopside, chlorite, calcite, serpentine, kaolin, magnetite, hematite, apatite, rutile, and leucoxene. Mainly feldspar and quartz.

H. Altered latite, same locality as F, wall rock of vein. Contains mainly quartz and kaolin, with diaspore, pyrite, sericite, rutile, and apatite.

I. Monzonitic porphyry, near Yankee Girl mine. *Adamellose.* Contains albite, quartz, orthoclase, chlorite, calcite, sericite, iron ores, pyrite, and apatite.

J. Altered monzonitic porphyry, near National Belle mine. Contains quartz, kaolin, pyrite, diaspore, sericite, apatite, and rutile.

Anaylses F to I by H. N. Stokes, record No. 1888.

	F	G	H	I	J
SiO_2	85.49	55.61	64.79	58.78	73.61
Al_2O_3	5.49	16.40	18.93	13.52	13.97
Fe_2O_3	.23	5.44	None.	1.70	None.
FeO	.25	2.37	None.	2.27	None.
MgO	None.	3.25	None.	3.29	None.
CaO	.27	5.85	.43	4.31	.31
Na_2O	None.	2.61	.15	3.24	.04
K_2O	None.	3.77	.24	4.06	.06
H_2O-	.46	.46	.50	.25	.58
H_2O+	3.07	1.51	5.39	1.57	4.18
TiO_2	.63	1.10	1.21	.99	.60
CO_2	None.	1.33	None.	3.49	None.
P_2O_5	.07	.45	.51	.53	.33
SO_3	.46	....	....	....	....
S	....	Trace.	....	....	....
FeS_2	3.43	....	7.19	1.56	5.62
MnO	None.	.09	None.	Trace.	Trace.
BaO	.07	.03	.06	.12	.04
SrO	....	.05	Trace.	.05	Trace.
Li_2O	....	Trace.	Trace.	Trace.	Trace.
	99.92	100.32	99.40	99.73	99.34

17. TELLURIDE QUADRANGLE.

Rocks collected by Whitman Cross. All except A described in Folio 57.

A. Lamprophyre, allied to camptonite, Black Face. *Andose.* **Consists of a fine felt of plagioclase, augite, and brown hornblende microlites, with flakes of biotite, and a cryptocrystalline part, which is probably in large degree orthoclase. Some magne-**

tite and apatite. Analysis by Hillebrand, record No. 1719. Sp. gr., 2.783, 22°. P. R. C. 1282.

B. Quartz monzonite, northeast of San Miguel Peak. *Toscanose.* Contains orthoclase and plagioclase in about equal amounts, with abundant quartz and much less augite, hornblende, biotite, magnetite, and apatite. Analysis by H. N. Stokes, record No. 1764. Sp. gr., 2.720, 34°. Described by Cross in 21st Ann., pt. 2. P. R. C. 1279.

C. Diorite monzonite, Ophir Needles. *Tonalose.* Contains abundant labradorite, with augite, hypersthene, biotite, orthoclase, magnetite, apatite, and a very little quartz. Analysis by Stokes, record No. 1764. Sp. gr., 2.860, 33°.

D. Gabbro porphyry, pass south of Mount Sneffels. *Andose.* Contains numerous phenocrysts of labradorite or bytownite, in a groundmass of plagioclase, orthoclase (?), augite, hypersthene, biotite, magnetite, and apatite. Analysis by Stokes, record No. 1764. Sp. gr., 2.949, 26.5°. P. R. C. 1280.

E. Vitrophyre, ridge east of Windy Gap. *Yellowstonose-lassenose.* P. R. C. 1281. Analysis by H. N. Stokes.

F. Gabbro, Stony Mountain, Ouray County. *Hessose.* Analyzed by Eakins in the Denver laboratory. Sp. gr., 2.891, 13.5°. P. R. C. 199.

	A	B	C	D	E	F
SiO_2	55.65	65.70	56.93	47.32	64.72	52.05
Al_2O_3	17.04	15.31	17.03	16.71	14.18	17.96
Fe_2O_3	2.81	2.54	3.67	6.92	1.58	4.09
FeO	5.17	1.62	4.54	5.94	.40	6.33
MgO	3.42	1.62	3.30	5.69	.50	5.03
CaO	6.82	2.56	6.51	8.51	2.62	8.64
Na_2O	3.27	3.62	3.19	2.70	3.88	2.99
K_2O	2.29	4.62	2.58	2.02	1.82	1.61
H_2O-	.46	.17	.13	.24	2.68	.97
H_2O+	1.49	.42	.45	1.04	6.82	
TiO_2	.90	.72	1.03	1.50	.43	
P_2O_5	.37	.33	.44	.96	.08	.31
MnO	.20	Trace.	.10	.08	Trace.	.43
SrO	.05	.03	.06	.06	.21	
BaO	.08	.12	.08	.07	.28	
Li_2O	Trace.	Trace.	None.	Trace.	None.	
CO_2		None.	None.	None.		
SO_3	None.	.12	None.	.19		
Cl		.03	Trace.	Trace.		
	100.02	99.53	100.04	99.95	100.20	100.41

18. SAN CRISTOBAL QUADRANGLE.

Rocks collected by Whitman Cross, who supplies the petrographic data.

A. Granite porphyry, Alpine Gulch. *Liparose.* Contains phenocrysts of quartz and microperthite in a groundmass of quartz and alkali feldspar. A very little biotite, apatite, and iron ore are present, with secondary calcite, chlorite, and sericite.

Analysis by R. C. Wells, record No. 2469.

B. Cooper rhyolite, Lake fork, opposite foot of trail up Campbell Gulch. *Magdeburgose.* Carries phenocrysts of quartz and microperthite in a groundmass of quartz and alkali feldspar. A little biotite and iron ore with some secondary calcite and sericite are also present.

C. Hinsdale rhyolite, valley of Big Spring Creek. *Liparose.* Carries phenocrysts of quartz and orthoclase in a groundmass of the same minerals. Also a little biotite and iron ore, with noteworthy tridymite.

D. Alboroto rhyolite, ridge west of north of mouth of Lost Trail Creek. *Toscanose.* Contains phenocrysts of orthoclase, plagioclase, and biotite, in a groundmass of quartz and orthoclase. Also some apatite, titanite, zircon, iron ore, etc. Analyses B, C, D, by Wells, No. 2836.

E. Hinsdale trachydolerite, 1 mile southeast of turn in Lost Trail Creek. *Shoshonose.* Contains phenocrysts of labradorite, olivine, and augite in a mat of andesine, labradorite, augite, iron ore, and alkali feldspar. Analysis by Chase Palmer, No. 2837.

	A	B	C	D	E
SiO_2	75.19	74.72	75.62	68.83	54.80
Al_2O_3	12.91	12.80	12.96	15.60	16.69
Fe_2O_3	.88	.59	1.00	2.11	5.18
FeO	.68	.83	.31	.56	2.73
MgO	None.	.04	.03	.60	3.61
CaO	.68	.62	.39	1.86	6.23
Na_2O	3.72	2.20	3.80	3.66	3.74
K_2O	5.30	6.32	5.20	5.09	3.57
H_2O-	.21	.55	.29	.44	.55
H_2O+	.47	.94	.48	.62	.37
TiO_2	.18	.44	.21	.47	1.14
ZrO_2	Trace.	.02	.02	.05	.07
CO_2	.11	.21	None.	None.	None.
P_2O_5	None.	.02	None.	.07	.78
F	....	....	....	....	.02
S	Trace.	.02	.01	.03	.01
Cr_2O_3	....	....	....	....	.005
V_2O_3	....	....	....	....	.03
MnO	.03	.13	.04	.05	.10
BaO	None.	.01	.01	.13	.17
SrO	....	.01	None.	None.	.04
	100.36	100.47	100.37	100.17	99.835

F. Quartz latite, north of head of Cascade Gulch. *Monzonose.* Contains phenocrysts of andesine-labradorite, augite, and biotite in a groundmass of quartz, alkali feldspar, etc.

G. Diorite, South Fork of West Lost Trail Creek. *Andose.* Contains labradorite, hypersthene, augite, orthoclase, quartz, biotite, iron ore, and apatite, with a little secondary calcite. Analyses F, G by Palmer, No. 2837.

H. Quartz latite, basin of Main Fork of Mineral Creek. *Adamellose.* Contains plagioclase, orthoclase, quartz, hornblende, augite, biotite, and titanite in a groundmass of quartz and alkali feldspar.

I. Piedra quartz latite, east slope of Trout Creek. *Amiatose.* Contains andesine-labradorite, augite, biotite, and hornblende in a groundmass of quartz and alkali feldspar.

J. Huerto pyroxene andesite, ridge west of east fork of Woodfern Creek. *Tonalose.* Contains labradorite, hypersthene, and augite in a groundmass of feldspar, pyroxene, iron ore, and probably glass. A little olivine is present.

Analyses H, I, J by G. Steiger, record No. 2842.

	F	G	H	I	J
SiO_2	60.25	53.60	62.36	62.64	57.28
Al_2O_3	15.55	17.89	14.95	17.46	17.55
Fe_2O_3	5.95	4.20	5.15	3.35	4.07
FeO	.53	5.45	.89	1.03	3.96
MgO	2.91	3.77	1.82	1.05	2.08
CaO	4.93	7.53	3.88	4.32	6.61
Na_2O	3.41	2.91	3.59	3.97	3.54
K_2O	4.39	1.98	3.74	3.94	2.00
H_2O-	.20	.55	1.52	.84	.94
H_2O+	.46	.64	.85	.56	.66
TiO_2	.51	.74	.69	.69	.81
ZrO_2	.04	.03	None.	.02	None.
CO_2	None.	.25	.10	None.	None.
P_2O_5	.61	.30	.31	.26	.38
F	.04	.02	....	....	....
S	.02	.05	.01	.02	.01
Cr_2O_3	Trace.	Trace.	None.	None.	None.
V_2O_3	.02	.03	.02	.03	.01
MnO	.09	.18	.09	.09	.16
BaO	.13	.08	.08	.10	.08
SrO	.05	.07	.07	.06	.05
	100.09	100.27	100.12	100.43	100.19

K. Huerto basalt, south of Huerto Peak. *Shoshonose*. Contains prominent crystals of labradorite, much olivine partly altered to iddingsite, and some pyroxene, in a crystalline aggregate of feldspar, pyroxene, iron ore, etc.

L. Alboroto quartz-latite, canyon of Texas Creek. *Riesenose*. Contains phenocrysts of andesine-labradorite, quartz, orthoclase, hornblende, augite, biotite, and sphene in a groundmass of quartz and alkali feldspar. Apatite, zircon, and iron ores are present.

M. Diorite, east of summit of Red Mountain. *Tonalose*. Contains, in order of abundance, andesine, augite, biotite, hypersthene, quartz, orthoclase, apatite, and iron ore.

N. Diorite porphyry, east side of Trout Creek. *Hessose*. Contains crystals of labradorite in a groundmass of labradorite, augite, hypersthene, biotite, quartz, and orthoclase.

Analyses K to N by W. T. Schaller, record No. 2864.

	K	L	M	N
SiO_2	54.06	66.39	60.00	52.09
Al_2O_3	19.07	18.16	18.10	21.35
Fe_2O_3	4.69	2.50	1.75	2.26
FeO	4.40	1.13	3.77	5.82
MgO	1.15	.85	2.41	2.57
CaO	6.78	3.71	5.30	8.17
Na_2O	3.20	1.96	3.36	3.28
K_2O	2.98	3.56	2.10	1.81
H_2O-	1.19	.66	.76	.57
H_2O+	.57	.56	.73	.53
TiO_2	1.38	.50	.93	1.47
ZrO_2	.03	.03	.02	.02
CO_2	None.	None.	Trace.	Trace.
P_2O_5	.62	.36	.63	.61
S	.02	.03	.02	.02
MnO	.15	.06	.13	.18
BaO	.07	.07	.09	.06
SrO	.01	.02	.01	.02
	100.37	100.55	100.11	100.83

19. LA PLATA MOUNTAINS.

Rocks described by Whitman Cross in Folio 60.

A. Monzonitic facies of diorite mass. *Akerose*. Contains augite, hornblende, plagioclase, and orthoclase in large amount, with biotite, quartz, sphene, apatite, and magnetite as subordinate constituents. Also secondary chlorite, muscovite, and calcite. Analysis by W. F. Hillebrand, record No. 1640. Sp. gr., 2.79, 21°. Described by Cross in 21st Ann., pt. 2. P. R. C. 1284.

B. Diorite porphyry, Deadwood Gulch. *Akerose*. Contains phenocrysts of hornblende, plagioclase, occasional quartz, sphene, apatite, and magnetite in a groundmass of orthoclase, plagioclase, and quartz. Also secondary epidote, chlorite, and calcite. Analysis by Hillebrand, record No. 1636. Sp. gr., 2.677, 24°. A trace of sulphur is present. Described by Cross in 21st Ann., pt. 2. P. R. C. 1283.

C. Augite syenite, between Tirbircio and Schurman gulches. *Monzonose*. Contains much alkali feldspar, some oligoclase, augite, biotite, and hornblende, with a little titanite, magnetite, and apatite. Analysis by H. N. Stokes, record No. 1764. Sp. gr. 2.704, 25°. P. R. C. 1286.

D. Augitic monzonite, Babcock Peak. *Andose*. Contains orthoclase and plagioclase in about equal amounts, with augite and hornblende, and a little quartz, titanite, magnetite, and apatite. Analysis by Stokes, record No. 1764. Sp. gr., 2.767, 26°. Described by Cross in 21st Ann., pt. 2. P. R. C. 1285.

E. Porphyritic lamprophyre, allied to camptonite, Snowstorm Peak. *Kentallenose.* Contains numerous phenocrysts of green hornblende, augite, and plagioclase, in a groundmass of plagioclase, orthoclase, augite, magnetite, and apatite. Some secondary calcite. Analysis by Hillebrand, record No. 1640. Sp. gr., 2.906, 21°. P. R. C. 1287.

F. Basic dike rock, Indian Trail Ridge, La Plata quadrangle. *Camptonose.* Contains phenocrysts of green hornblende and colorless diopside in a subordinate groundmass of plagioclase, orthoclase (?), augite, magnetite, and apatite. Much secondary calcite and some serpentine. Analysis by W. F. Hillebrand, record No. 1640. Sp. gr., 2.912, 19.5°. P. R. C. 1288.

	A	B	C	D	E	F
SiO_2	55.53	60.44	59.79	57.42	47.25	43.98
Al_2O_3	16.78	16.65	17.25	18.48	15.14	13.30
Fe_2O_3	4.06	2.31	3.60	3.74	5.05	3.67
FeO	3.35	3.09	1.50	2.10	4.95	6.92
MgO	3.00	2.18	1.24	1.71	6.87	7.03
CaO	6.96	4.22	3.77	6.84	9.98	10.66
Na_2O	4.31	5.18	5.04	4.52	2.39	2.15
K_2O	3.57	2.71	5.05	3.71	2.60	1.64
H_2O-	.09	.36	.19	.08	.40	.42
H_2O+	.55	1.07	.39	.28	2.12	1.52
TiO_2	.95	.60	.67	.86	1.22	1.18
P_2O_5	.47	.29	.35	.36	.25	.32
V_2O_3	.02	.02	......	......	.05	......
NiO, CoO	Trace.	None.	......	......	.02	.03
MnO	.16	.13	.20	.09	.17	.22
SrO	.11	.11	.11	.08	.06	.05
BaO	.13	.12	.14	.15	.08	.06
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
CO_2	.09	.48	.72	None.	1.87	6.46
SO_3	......	......	.04	None.	......	......
Cl	......	......	Trace.	.03	......	......
FeS_2	.04	......	......	......	None.	.54
	100.17	99.96	100.14	100.45	100.46	100.15

20. MISCELLANEOUS ROCKS.

A. Diabase, east of the Sugar Loaf, Boulder County. *Hessose.* Description furnished by Whitman Cross. The rock contains labradorite, orthoclase, augite, and magnetite, with small amounts of hornblende, biotite, apatite, and secondary chlorite. Sp. gr., 3.027, 21°. P. R. C. 166.

B. Pyroxene separated from A. Analyses A, B, made by L. G. Eakins in the Denver laboratory.

C. Granite, Platte Canyon. *Alaskose.* Described by E. B. Mathews in Bull. 150, p. 172. Contains microcline, quartz, biotite, oligoclase, and fluorite. Apatite, zircon, magnetite, hematite, limonite, epidote, and rutile (?) are sometimes present. Analysis by H. N. Stokes, record No. 1314.

D. Nepheline tephrite, Elkhead Mountain, Routt County. Undescribed. Sp. gr., 2.888, 12.2°.

E. Portion of N soluble in hydrochloric acid. Recalculated to 100 per cent, 39.95 per cent of the entire rock. Analyses D, E, made by L. G. Eakins in the Denver laboratory.

F. Olivine basalt, Pilot Knob, Routt County. Collected by H. S. Gale, who furnishes the description. Contains plagioclase, olivine, augite, magnetite, apatite, and possibly other accessory minerals. Analysis by W. F. Hillebrand, record No. 2235. P. R. C. 1870.

	A	B	C	D	E	F
SiO_2	48.93	47.32	77.02	46.67	45.51	48.16
Al_2O_3	20.99	6.37	11.63	15.90	18.40	12.85
Fe_2O_3	2.02	2.56	.32	3.20	8.02	2.79
FeO	9.36	14.40	1.09	7.04	9.58	7.11
MgO	4.39	13.43	.14	10.17	6.78	10.45
CaO	8.03	16.08	1.24	9.15	4.61	8.13
Na_2O	3.06		2.85	3.20	4.90	3.18
K_2O	1.80		5.21	2.54	2.20	2.79
H_2O-	1.18		.35	1.64		.45
H_2O+						1.47
TiO_2						1.50
ZrO_2						Trace.
P_2O_5	.15			.64		.70
S	Trace.					Trace.
SO_3				Trace.		
Cl				.11		Undet.
Cr_2O_3						.07
CoO, NiO						.04
MnO	.31		Trace.	Trace.		.14
BaO						.25
SrO						.15
Li_2O						Trace.
Cu						Trace.
	100.22	100.16	99.85	100.26	100.00	100.23

G. Rhyolite, east bank of Arkansas River, Nathrop. *Liparose.* Described by Cross in Proc. Colorado Sci. Soc., vol. 2, p. 69. Contains quartz and sanidine in a groudmass mainly of quartz and alkali feldspar. This rock carries topaz and spessartite in its lithophysæ. Analysis made by L. G. Eakins in the Denver laboratory. Sp. gr., 2,602, 29°. P. R. C. 598.

H. Hornblende porphyrite, Hermano Peak, Sierra El Late. *Lassenose.* Described by Cross in 14th Ann., p. 165. Contains plagioclase, hornblende, rare quartz, and a little biotite. Analysis by W. F. Hillebrand, record No. 1429.

I. Hornblende porphyrite, Ute Peak, Sierra El Late. *Tonalose.* Described by Cross in 14th Ann., p. 165. Contains plagioclase, hornblende, and very little augite, in a groundmass of quartz, orthoclase, and plagioclase. Analysis by Hillebrand, No. 1429.

J. Porphyritic augite diorite, Lone Cone, San Miguel Mountains. *Tonalose.* Described by Cross in 14th Ann., p. 165. Contains plagioclase, augite, hornblende, and biotite, in a groundmass of quartz, orthoclase, and plagioclase. Inclusions of magnetite and apatite in the augite. Analysis by Hillebrand, No. 1429.

	G	H	I	J
SiO_2	69.89	62.65	59.42	59.19
Al_2O_3	17.94	16.68	16.79	18.00
Fe_2O_3	.39	2.35	3.23	3.07
FeO	.52	2.63	3.29	2.32
MgO	.14	1.43	2.24	1.41
CaO	Trace.	4.96	5.57	6.55
Na_2O	4.21	4.45	4.15	4.01
K_2O	4.38	2.75	2.82	2.74
H_2O-	2.07	.27	.27	.46
H_2O+		.66	.79	1.06
TiO_2		.42	.68	.58
P_2O_5	Trace.	.28	.35	.29
MnO	.23	.16	.13	.19
SrO		.11	.07	.13
BaO		.13	.14	.18
Li_2O	Trace.	Trace.	Trace.	Trace.
CO_2			.44	
	99.77	99.93	100.38	100.18

K. Tinguaite (?), Two Buttes. *Laurdalose*. Collected by G. K. Gilbert; petrographic data supplied by Whitman Cross. Consists chiefly of pale-green augite, hornblende, apatite, magnetite, and occasional crystals of alkali feldspar, in an obscure, largely isotropic groundmass. Sp. gr., 2.79, 25°. P. R. C. 1393.

L. Pyroxene from F. Sp. gr., 3.43, 28°.

M. Portion of F soluble in 1:40 nitric acid.

N. Syenitic lamprophyre (?), Two Buttes. *Prowersose*. Collected by Gilbert; described by Cross in Jour. Geol., vol. 14, p. 165. Chief constituents, diopside, alkali feldspar, considerable biotite, magnetite, and olivine. The ferromagnesian minerals predominate. Sp. gr., 2.88, 29°. P. R. C. 1394.

O. Pyroxene from I. Sp. gr., 3.45, 25°.

P. Portion of I soluble in 1: 40 nitric acid.

Analyses F to K by W. F. Hillebrand, record No. 1604.

	K	L	M	N	O	P
SiO_2	47.61	47.54	13.27	50.41	51.27	1.58
Al_2O_3	14.26	4.14	9.40	12.27	3.05	1.00
Fe_2O_3	4.90	5.64	....	5.71	3.08	None.
FeO	4.07	6.42	Trace.	3.06	4.34	.87
MgO	2.62	10.05	Trace.	8.69	14.21	1.22
CaO	8.71	21.57	1.70	7.08	22.58	.68
Na_2O	6.70	1.38	5.41	.97	.67	Undet.
K_2O	4.08	.12	.66	7.53	.06	Undet.
H_2O-	.26	None.	Undet.	.46	None.	None.
H_2O+	1.89	Undet.	Undet.	1.80	Undet.	Undet.
TiO_2	1.38	3.00	....	1.47	.70	....
P_2O_5	1.38	....	1.34	.46	....	.46
ZrO_2	.18	None.	....	None.	None.	....
Cr_2O_3	Trace?	Trace?	....	Trace.	None.	....
V_2O_3	....	....	....	.03	....	....
NiO	Trace.	Trace.	....	.04	.03	....
MnO	.30	.36	Trace.	.15	.28	Trace.
SrO	.36	None.	.11	.06	None.	(?)
BaO	.41	None.	None.	.23	None.	None.
Li_2O	Trace.	Trace.	(?)	Trace.	....	....
SO_3	1.17	....	.77	None.	....	....
S	.03	....	.03	None.	....	....
Cl	.37	....	.37	Trace.	....	Trace.
F	Trace.	....	Trace.	Trace?	....	....
	100.68	100.21	33.06	100.42	100.27	5.81

Rocks Q to T collected by Whitman Cross, who supplies the petrographic data.

Q. Rhyolitic vitrophyre, near Del Norte, Rio Grande County. *Toscanose*. Reported by Cross as containing phenocrysts of oligoclase, quartz, biotite, and augite in a dark, fresh, glassy groundmass, the latter being predominant. Analysis made by Eakins in the Denver laboratory. Sp. gr., 2.423, 14°. P. R. C. 164.

R. Rhyolite, Summit district, Rio Grande County. *Toscanose*. Large phenocrysts of sanidine, with smaller ones of oligoclase and biotite, in a groundmass of orthoclase, quartz, oligoclase, biotite, and magnetite. Analysis by Eakins, made in the Denver laboratory. Sp. gr., 2.489, 14°.

S. Quartz-trachyte, Grayrock Peak, Engineer Mountain quadrangle. *Liparose*. Described by Cross in Folio 171. Contains alkali feldspar, plagioclase, quartz, biotite, hornblende, augite, magnetite, apatite, and titanite. Analysis by G. Steiger, record No. 2374. P. R. C. 1763.

T. Quartz-mica schist, Vernal Mesa, three-fourths mile east of south of Nyswonger Spring, Gunnison Canyon. Consists of quartz, biotite, muscovite, and feldspar, with some zircon and ore particles. Analysis by Steiger, No. 2664.

	Q	R	S	T
SiO_2	68.61	68.85	70.73	71.06
Al_2O_3	16.43	17.01	14.22	13.23
Fe_2O_3	.73	1.78	1.59	1.17
FeO	1.52	.65	.59	3.57
MgO	.05	Trace.	None.	.95
CaO	1.79	1.62	.72	1.48
Na_2O	2.82	3.44	4.96	3.98
K_2O	4.65	5.11	5.57	2.74
H_2O-	3.35	1.79	1.16	.32
H_2O+			.32	1.16
TiO_2			.34	.60
ZrO_2			.04	.02
P_2O_5			.03	.16
S				.02
MnO		Trace.	.11	.13
BaO			.01	None.
	99.95	100.25	100.39	100.59

UTAH.

1. THE TINTIC DISTRICT.

Described by Tower and Smith in 19th Ann., pt. 3, pp. 609 et seq. Analyses by Stokes, record No. 1746.

A. Gray, porphyritic rhyolite, south of Pinyon Creek. *Toscanose*. Contains phenocrysts of sanidine, quartz, biotite, plagioclase, and hornblende; the last mineral sparingly. Also tridymite, magnetite, apatite, zircon, and a small amount of glassy residue. P. R. C. 1039.

B. Quartz porphyry, Swansea mine. *Toscanose*. Phenocrysts of feldspar and quartz, the orthoclase somewhat altered. Microscopic biotite occurs sparingly. Also contains magnetite, apatite, zircon, a little chlorite, and secondary pyrite. P. R. C. 1040.

C. Andesite, Tintic Mountain. *Harzose*. Phenocrysts of biotite and feldspar. Contains plagioclase, chiefly labradorite, augite, biotite, hypersthene, magnetite, and apatite, in a dark-gray glass. P. R. C. 1036.

D. Granular monzonite, Iron Duke mine. *Harzose*. Contains orthoclase, plagioclase, quartz, hornblende, biotite, magnetite, apatite, zircon, and titanite, with a little chlorite and epidote. P. R. C. 1032.

E. Altered monzonite, near Tintic mine. Feldspar and ferromagnesian minerals completely altered. Rutile is present; quartz seems to have been added.

	A	B	C	D	E
SiO_2	69.18	71.56	60.17	59.76	71.14
Al_2O_3	14.36	14.27	15.77	15.77	16.22
Fe_2O_3	2.52	.89	3.42	3.77	.94
FeO	.57		2.95	3.30	.16
MgO	.70	.42	2.52	2.16	1.12
CaO	1.88	1.18	4.69	3.88	.25
Na_2O	3.58	3.00	2.96	3.01	.07
K_2O	5.00	4.37	4.16	4.40	4.96
H_2O-	.35	.36	.25	.31	.49
H_2O+	.25	.79	1.23	1.11	2.74
TiO_2	.69	.38	.87	.87	.75
P_2O_5	.26	.13	.40	.42	.32
Cr_2O_3	Trace.	Trace.	None.	None.	None.
V_2O_3	.01	.01	.01	.02	.02
MnO	.10	Trace.	.11	.12	Trace.
BaO	.09	.28	.14	.09	.05
SrO	Trace.	Trace.	.09	Trace.	Trace.
Li_2O	Trace.	None.	Trace.	Trace.	Trace.
CO_2	None.	None.	None.	.78	None.
S	None.		None.	None.	
SO_3	None.		None.	None.	.26
FeS_2		2.29			
Cl	Trace.	.06	.04	.04	Trace.
	99.54	99.99	99.78	99.81	99.49

Fluorine was not looked for in these analyses.

2. HENRY MOUNTAINS.

A. Porphyry. *Tonalose.* Not hitherto published. Reported by J. S. Diller as containing prominent plagioclase with some augite and hornblende in a crystalline groundmass of quartz and orthoclase. Analyses by R. B. Riggs, record No. 728.

B. Augite porphyrite, dike, north spur of Mount Pennell. *Laurvikose.* Contains hornblende, augite, and plagioclase in a feldspathic groundmass.

C. Hornblende porphyrite, Mount Hillers. *Tonalose.* Contains plagioclase, hornblende, quartz, and magnetite.

Analyses B and C by W. F. Hillebrand, record No. 1428. Rocks described by Cross in 14th Ann., p. 165.

	A	B	C
SiO_2	63.16	60.98	62.88
Al_2O_3	17.21	19.09	17.13
Fe_2O_3	2.43	1.76	1.86
FeO	2.30	1.15	2.58
MgO	1.27	.65	1.48
CaO	6.27	3.67	5.39
Na_2O	4.70	6.70	4.50
K_2O	1.84	3.53	2.25
H_2O-	....	.48	.16
H_2O+	.69	.44	.42
TiO_2	.21	.36	.51
P_2O_5	.12	.10	.26
MnO	Trace.	.15	.16
SrO	Trace?	.28	.12
BaO	.09	.43	.16
Li_2O	Trace.	Trace.	Trace.
CO_2	....	.52	....
SO_3	Trace.	....	....
	100.29	100.29	99.86

3. LA SAL MOUNTAINS.

Petrographic descriptions by L. M. Prindle. Analyses by W. F. Hillebrand, record No. 2032.

A. Monzonite porphyry, 2 miles west of Mount Peale. *Akerose.* Contains phenocrysts of plagioclase, partly resorbed hornblende, and pyroxene in a groundmass of partly striated feldspar. It may contain also orthoclase and quartz. P. R. C. 1306.

B. Ægirite granite porphyry, about 1.5 miles south of Mount Waas. *Omeose-liparose.* Contains quartz, feldspar, pyroxene, and iron ore. The pyroxene is probably for the most part ægirite. P. R. C. 1304.

C. Syenite-aplite porphyry resembling grorudite. About 2 miles south of Mount Waas. *Liparose.* Contains potash and soda-lime feldspars, quartz, pyroxene, titanite, and iron ore. In the groundmass are needles which are probably ægirite. P. R. C. 1301.

D. Syenite porphyry resembling sölvsbergite. About 1 mile northwest of Mount Waas. *Phlegrose near nordmarkose.* Contains potash and soda-lime feldspars, quartz, pyroxene, and iron ore. Needles of ægirite (?) in the groundmass. P. R. C. 1303.

E. Pulaskite, 1 mile west of Mount Waas. *Nordmarkose.* Contains potash feldspar, pyroxene, biotite, apatite, titanite, and iron ore. P. R. C. 1305.

F. Noselite syenite porphyry, dike on northwest shoulder of Mount Waas. *Miaskose.* Contains feldspar, pyroxene, sodalite or noselite, apatite, titanite, and iron ore. The pyroxene appears to be mostly ægirine-augite and the feldspar mainly potash feldspar. P. R. C. 1302.

	A	B	C	D	E	F
SiO_2	61.21	73.27	70.02	68.96	62.64	58.99
Al_2O_3	17.10	13.29	14.38	15.42	17.36	19.01
Fe_2O_3	2.72	1.16	1.17	1.99	2.79	1.74
FeO	1.88	.13	.13	.16	.63	.59
MgO	1.47	.07	.61	.22	.53	.27
CaO	4.83	.21	.66	.25	1.70	2.02
Na_2O	5.66	3.44	5.48	6.59	7.00	9.11
K_2O	3.00	7.53	5.87	5.48	4.97	5.07
H_2O-	.34	.23	.27	.22	.43	.38
H_2O+	.68	.43	.44	.30	.53	1.24
TiO_2	.51	.10	.10	.12	.43	.21
ZrO_2	.02	.02	.01	.04	.02	.07
CO_2	None.	.02	.38	.13	.54	None.
P_2O_5	.24	Trace.	Trace.	Trace.	.12	.04
SO_3	None.	.07	.19	None.	.06	.96
Cl	.04	.01	.03	.01	.03	.15
MnO	.15	.03	.02	.07	.04	.08
BaO	.13	.10	.13	Trace.	.10	.02
SrO	.07	None?	.06	None.	.07	.02
Li_2O	Trace?	Trace.	Trace.	Trace.	None.	Trace.
	100.05	100.11	99.95	99.96	99.99	99.97

S absent from all.

4. THE BINGHAM DISTRICT.

Rocks A to D are porphyries collected by J. M. Boutwell, and described in P. P. 38, p. 178. Analyses by E. T. Allen, record No. 1985.

A. From Tribune Tunnel, Telegraph mine. *Monzonose.*

B, C, D. From British Tunnel, Last Chance mine. B, *Sr. 1 of dacase.* C, *harzose.* D, *monzonose.* According to Boutwell, A is the characteristic Bingham porphyry, and is intermediate between diorite porphyry and monzonite. It contains chiefly augite, biotite, and plagioclase, with a few grains of pyrite. B, C, D are altered forms of this rock.

E. Altered porphyry. Contains biotite, orthoclase, muscovite, quartz, and rutile. Sp. gr. 2.58.

F. Altered porphyry. Contains quartz, orthoclase, muscovite, rutile, and very little biotite. Sp. gr. 2.43.

Rocks E, F were collected by B. S. Butler, who supplies the petrographic data. Analyses by G. Steiger, record No. 2724.

	A	B	C	D	E	F
SiO_2	57.16	56.78	56.17	58.64	63.09	66.27
Al_2O_3	16.69	16.90	15.94	15.35	16.33	15.01
Fe_2O_3	3.47	6.87	3.43	3.25	1.37	1.84
FeO	2.76	2.34	1.92	2.54	3.29	.39
MgO	2.47	.03	1.60	3.84	3.53	.71
CaO	5.86	1.18	5.19	5.37	.70	.18
Na_2O	3.82	.37	2.48	3.60	2.79	.72
K_2O	4.49	7.02	4.91	4.23	3.91	9.62
H_2O-	.83	1.32	1.30	.86	.95	.34
H_2O+	1.06	2.23	2.95	1.50	2.35	1.50
TiO_2	.87	.81	.90	.83	.43	.47
CO_2	None.	.26	2.01	None.	None.	None.
P_2O_5	.41	.04	.20	.02	.42	.16
F	......	......	......	......	.08	.15
S	.02	5.93	1.03	.05	.67	1.66
Cr_2O_3	Trace.	Trace.	......	Trace.	......	......
MnO	Trace.	Trace.	Trace.	Trace.	None.	None.
BaO	.30	.14	.18	.18	.09	.17
SrO	......	......	......	......	Trace.	Trace.
CuO	......	......	......	......	.55	1.62
	100.21	102.22	100.21	100.26	100.55	100.81
Less O	.01	2.22	.39	.02	.37	.90
	100.20	100.00	99.82	100.24	100.18	99.91

5. THE PARK CITY DISTRICT.

Rocks collected by J. M. Boutwell and described in P. P. 77. Analyses by W. F. Hillebrand, record No. 2173.

A. Granite (?), head of Big Cottonwood Canyon. *Lassenose.* Essential constituents quartz, orthoclase, plagioclase, biotite, hornblende, and augite, with accessory apatite and perhaps sphene.

B. Quartz diorite, east side of Brighton Gap. *Harzose.* Contains oligoclase, quartz, orthoclase, hornblende, and biotite, with accessory pyrite, apatite, and titanite. A little secondary kaolinite and chlorite. P. R. C. 1913.

C. Quartz diorite porphyry, Valeo mine. Contains plagioclase, hornblende, biotite, and quartz, with pyrite and some orthoclase, and secondary calcite, chlorite, and kaolin. P. R. C. 1914.

D. Quartz diorite porphyry, dike northwest of Daly West mine. Contains albite, hornblende, quartz, pyrite, and possibly apatite, with secondary chlorite or serpentine, calcite, epidote, kaolin, and muscovite. P. R. C. 1912.

E. Quartz diorite, Clayton Peak Amphitheater. *Monzonose.* Contains plagioclase, orthoclase, hornblende, biotite, and augite, with accessory quartz, apatite, titanite, magnetite, and pyrite. P. R. C. 1915.

F. Andesite, Ontario drain tunnel. Contains albite, hornblende, some quartz and magnetite. A green secondary mineral is probably serpentine. P. R. C. 1911.

	A	B	C	D	E	F
SiO_2	65.27	63.46	61.64	59.68	59.35	54.23
Al_2O_3	15.75	15.93	14.66	15.61	16.36	17.37
Fe_2O_3	2.31	2.61	1.95	2.49	2.90	4.00
FeO	1.85	2.31	1.68	2.38	3.36	1.95
MgO	1.62	2.27	2.55	2.52	3.08	3.00
CaO	4.09	4.33	4.65	4.63	5.03	6.67
Na_2O	3.92	3.66	2.71	3.96	3.73	2.96
K_2O	3.25	3.49	3.07	2.96	3.85	2.80
H_2O-	.21	.27	1.04	.51	.28	1.60
H_2O+	.53	.74	2.56	2.00	.64	3.71
TiO_2	.55	.62	.48	.62	.87	.75
ZrO_2	.02	.03	.01	.01	.03	.02
CO_2	Trace.	Trace.	2.15	2.29	Trace?	.33
P_2O_5	.25	.16	.24	.29	.44	.34
Cl	.01	.05	Trace.	None.	.05	Trace.
F	(?)	Trace?	Trace.	(?)	(?)	(?)
S	....	Trace.	....	....	....	....
MnO	.10	.09	.06	.08	.07	.10
BaO	.11	.15	.18	.15	.16	.15
SrO	.05	Undet.	.06	.07	.05	.06
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
FeS_2	.02	....	.32	.02	.02	.02
CuO	....	....	....	....	.01	....
ZnO	....	....	....	....	.01	....
	99.91	100.17	100.01	100.27	100.29	100.06

Cr_2O_3 and SO_3 absent.

6. THE SAN FRANCISCO DISTRICT.

Rocks collected by B. S. Butler and described in P. P. 80.

A. Quartz monzonite, Cactus Tunnel. *Tonalose.* Contains plagioclase, orthoclase, hornblende, quartz, and pyroxene, with accessory iron ore, titanite, and apatite. Analysis by G. Steiger, record No. 2403. Sp. gr. 2.72.

B. Quartz monzonite, O K mine. *Amiatose.* Contains orthoclase, plagioclase, hornblende, biotite, magnetite, zircon, titanite, and apatite. Sp. gr. 2.64.

C. Altered quartz monzonite, O K mine. Sp. gr. 2.27.

D. Altered quartz monzonite, Cactus mine. Sp. gr. 2.53.

E. Altered lava, ridge west of O K mine. Essentially a quartz-andalusite-muscovite rock. Partial analysis.

Analyses B to E by R. C. Wells, record Nos. 2443, 2450.

	A	B	C	D	E
SiO_2	62.10	64.41	66.87	62.56	72.32
Al_2O_3	15.47	15.85	18.14	17.21	20.96
Fe_2O_3	2.64	1.92	1.36	2.29	.50
FeO	3.15	2.52	1.06	3.64	
MgO	2.57	1.66	.68	1.13	None.
CaO	5.31	3.71	.11	.29	.15
Na_2O	3.56	3.60	.61	.07	.55
K_2O	3.15	3.46	4.12	6.02	.93
H_2O-	.14	.12	.87	.14	[a] 3.91
H_2O+	.72	1.09	4.05	2.70	
TiO_2	.81	.43	.85	.70	1.10
CO_2	Trace.	.72	None.	1.93	....
P_2O_5	.27	.23	.05	.24	....
SO_3	....	None.	.05	.02	....
S	....	....	.23	.13	....
Cu	....	....	.70	.09	....
MnO	....	.07	None.	.45	....
	99.89	99.79	99.75	99.61	100.42
Less O	....	....	.11	.06	....
	....	....	99.64	99.55	....

[a] Loss on ignition.

7. MISCELLANEOUS ROCKS.

A. Rhyolite, Thomas Range. *Toscanose.* Analysis made by L. G. Eakins in the Denver laboratory. Described by Cross in Proc. Colorado Sci. Soc., vol. 2, p. 69. Contains phenocrysts of quartz and sanidine in a groundmass mainly made up of quartz and alkali feldspar.

B. Rhyolitic glass or pitchstone, edge of Gold Mountain mining district, 8 miles north of west from Marysvale. *Liparose.* Identified by Whitman Cross. Sp. gr., 2.25 at 23.5°. Analysis by W. F. Hillebrand, record No. 1833.

C. Altered latite, Rocky Range district.

D. Quartz monzonite, Clifton district. *Adamellose.* Contains plagioclase, orthoclase, quartz, hornblende, biotite, augite, magnetite, apatite, and titanite.

E. Ibapah granite, Deep Creek Range. *Toscanose.* Contains quartz, orthoclase, plagioclase, biotite, muscovite, iron ore, titanite, apatite, and rutile.

F. Little Cottonwood granite. *Toscanose.* Contains quartz, orthoclase, plagioclase, biotite, hornblende, magnetite, titanite, apatite, and zircon.

Rocks C to F collected by B. S. Butler, who supplies the petrographic data. Analyses by R. C. Wells, record Nos. 2443, 2819.

	A	B	C	D	E	F
SiO_2	74.49	70.17	73.09	62.84	70.67	67.02
Al_2O_3	14.51	11.83	16.72	14.21	16.24	15.78
Fe_2O_3	.57	.93		.91	.37	1.56
FeO	.32	None.		3.75	1.15	2.18
MgO	Trace.	.06	.50	3.04	.26	1.09
CaO	1.03	.76	.20	4.72	1.71	3.31
Na_2O	3.79	3.85	3.92	2.85	3.95	3.85
K_2O	4.64	3.74	2.97	4.60	4.85	3.67
H_2O-	.64	8.72	2.85	.26	.29	.29
H_2O+				1.23	.64	.63
TiO_2	....	.17	....	.42	.23	.37
ZrO_2	....	....	....	Trace.	None.	.04
CO_2	....	....	.02	.38	Trace.	None.
P_2O_5	....	....	....	.41	.11	.26
S	....	....	.09	.01	.01	.03
MnO	Trace.	....	....	.06	.03	.02
BaO	....	....	....	.03	.05	.13
Li_2O	Trace.	....	....	....	....	....
	99.99	100.23	100.36	99.72	100.56	100.23

NEW MEXICO.

1. BASALTS FROM RIO GRANDE CAÑON.

Described by Iddings, Bull. 66; also in Am. Jour. Sci., 3d ser., vol. 36, p. 220. Contain plagioclase, augite, olivine, and magnetite. A, B, and C contain quartz also; D is quartzless. Analyses by L. G. Eakins, record Nos. 847, 850. All *andose*.

A. Light gray, dense. P. R. C. 548.

B. Greenish black, dense.

C. Dark red, vesicular. P. R. C. 549.

D. Gray, dense. P. R. C. 547.

	A	B	C	D
SiO_2	52.27	52.37	51.57	52.38
Al_2O_3	17.68	17.01	17.72	18.79
Fe_2O_3	2.51	1.44	6.24	2.88
FeO	5.00	5.89	1.78	4.90
MgO	6.05	6.86	4.91	4.91
CaO	8.39	7.59	8.82	7.70
Na_2O	4.19	3.51	3.59	3.99
K_2O	1.58	1.59	1.99	1.76
H_2O	.82	1.29	.64	.53
TiO_2	1.49	1.60	1.43	1.22
P_2O_5	....	....	....	.56
MnO	.23	.32	.45	.18
BaO	.06	.06	.16	.11
CO_2	Trace.	.37	.58	....
Cl	Trace.	Trace.	....	....
	100.27	99.90	99.88	99.91

2. MOUNT TAYLOR REGION.

Rocks received from J. S. Diller. Analyses by T. M. Chatard, record Nos. 219, 227, 228, 235, 271, 268, and 269. Petrographic details furnished by Diller.

A. Lava, canyon on east side of San Mateo Mountain. *Kallerudose*.

B. Andesite, canyon on east side of San Mateo Mountain. *Nordmarkose*. Contains feldspar and corroded augite, with sometimes olivine, in a groundmass of feldspar and a green ferromagnesian silicate. P. R. C. 1402.

C. Quartz latite, canyon on east side of San Mateo Mountain. *Lassenose*. Shows prominent plagioclase, with augite and biotite. P. R. C. 1403.

D. Dacite, 6 miles northeast of Grants. Principally plagioclase and biotite, with less epidote, quartz, sphene, and carbonates. P. R. C. 1401.

E. Basalt, 6 miles northeast of Grants. *Auvergnose*. Contains chiefly plagioclase, augite, and olivine, with much magnetite. P. R. C. 1400.

F. Augite from E.

G. Feldspar from E. Analysis on three-fourths gram of material.

	A	B	C	D	E	F	G
SiO_2	68.40	65.51	65.78	49.80	47.54	47.06	52.54
Al_2O_3	17.99	16.89	17.32	15.33	16.73	7.77	31.26
Fe_2O_3	2.66	1.41	3.68	....	6.69	1.30	....
FeO	1.63	2.52	.46	7.44	6.67	8.15	....
MgO	.49	.39	.47	6.61	6.38	13.52	.28
CaO	.67	1.19	1.66	7.19	8.74	19.33	12.34
Na_2O	4.54	6.42	5.23	2.71	2.81	.33	3.55
K_2O	3.54	5.02	4.64	4.36	1.10	.11	.42
H_2O	.52	.16	.14	1.38	.36	.20	.26
TiO_2	....	.92	.27	2.67	2.76	1.82	Undet.
P_2O_5	....	.07	.13	.73	.51	.06	....
Cr_2O_3	....	....	....	....	....	Trace.	....
MnO	.21	.31	.32	.30	.19	.20	....
(CoNi)O	....	....	....	....	....	Traces.	....
BaO	....	....	....	....	.03	....	Trace?
CO_2	....	....	....	2.56	(?)	....	....
	100.65	100.81	100.10	101.08	100.51	99.85	100.65

3. COLFAX COUNTY.

Rocks A to D described by Whitman Cross. Analyses by W. F. Hillebrand, record No. 1719.

A. Phonolite, Pleasant Valley. *Miaskose.* Contains much nephelite, some ægirite, alkali feldspar, a scanty dust of magnetite, and a few decomposed grains of noselite or sodalite. Sp. gr., 2.619, 22°; 40.8 per cent soluble in dilute (1:40) nitric acid, of which soluble portion 43.5 per cent is silica. P. R. C. 1334.

B. Pyroxene andesite, Sierra Grande. *Tonalose.* Contains augite, less hypersthene, microliths of plagioclase, apatite, magnetite, and a smoky-brown glassy base. Sp. gr., 2.635, 21°. P. R. C. 1335.

C. Plagioclase basalt, end of San Rafael flow. *Camptonose.* Contains plagioclase, augite, olivine, with much iddingsite, magnetite, and apatite. Sp. gr., 2.970, 21.5°. P. R. C. 1336.

D. Nepheline basanite, Ciruella. *Limburgose.* Contains augite, olivine, nephelite, plagioclase, magnetite, apatite, and a little biotite. Sp. gr., 3.122, 22°. 0.55 per cent K_2O and 2.10 per cent Na_2O soluble in 1:40 nitric acid. P. R. C. 1337.

	A	B	C	D
SiO_2	56.24	60.16	48.35	42.35
Al_2O_3	21.43	15.34	15.47	12.29
Fe_2O_3	2.01	3.07	4.80	3.89
FeO	.55	2.18	7.58	7.05
MgO	.15	3.41	8.15	13.09
CaO	1.38	5.79	8.81	12.49
Na_2O	10.53	3.88	3.09	2.74
K_2O	5.74	2.59	.95	1.04
H_2O-	.12	.25	.28	.32
H_2O+	.86	1.79	.73	1.50
TiO_2	.26	.84	1.33	1.82
P_2O_5	.06	.46	.33	.99
ZrO_2	.09	.01	None.	None.
Cr_2O_3	None.	Trace?	Trace.	.10
V_2O_3	....	....	....	.04
NiO, CoO	None.	Trace.	.02	.03
MnO	.08	.08	.21	.21
SrO	.03	.08	.03	.09
BaO	.08	.14	.06	.10
Li_2O	Trace.	Trace.	Trace.	Trace.
SO_3	.10	.08	.07	.05
S	.03	Trace.	Trace.	Trace.
Cl	.12	Undet.	Undet.	Undet.
F	Trace.	Undet.	Undet.	Undet.
	99.86	100.15	100.26	100.19

Rocks E to K, from the Raton-Mesa region, were collected by W. T. Lee, and studied by J. B. Mertie, who supplies the petrographic data. Analyses E, F, G, by J. G. Fairchild; record No. 2574, H, I, J, K, by G. Steiger. No. 2573.

E. Hornblende hyalorhyolite, from Red Mountain, Johnsons Mesa. *Lassenose.* Contains andesine, hornblende, magnetite, and much glass.

F. Augite andesite, mesa west of Johnsons Park. *Piedmontose.* Contains labradorite, orthoclase, augite, iddingsite, magnetite, hornblende, analcite, and glass.

G. Augite andesite, same locality as F. *Akerose.* Contains andesine, orthoclase, augite, magnetite, and apatite.

H. Olivine basalt, Mount Capulin, about 5 miles southwest of Folsom. *Camptonose.* Contains labradorite, augite, magnetite, olivine, apatite, and glass.

I. Olivine basalt, east rim of Barella Mesa. *Andose.* Contains labradorite, augite, iddingsite, magnetite, and apatite.

J. Olivine basalt, south rim of Barella Mesa. *Camptonose.* Contains labradorite, augite, olivine (partly altered to iddingsite), magnetite, and apatite.

K. Nepheline basalt, from volcanic flow near Yankee. *Limburgose.* Contains augite, nephelite, olivine, and magnetite.

	E	F	G	H	I	J	K
SiO_2	67.98	54.08	53.52	53.27	51.68	49.73	40.72
Al_2O_3	15.53	21.87	17.88	15.43	15.05	15.46	15.03
Fe_2O_3	2.68	5.22	4.21	2.43	5.22	3.32	5.52
FeO	.18	.88	3.51	6.50	5.64	8.14	6.86
MgO	1.47	2.69	3.90	6.16	5.63	7.20	8.29
CaO	3.39	5.53	7.36	8.18	8.30	9.63	13.95
Na_2O	4.53	5.46	5.19	3.51	3.75	3.30	4.01
K_2O	3.00	2.88	2.39	1.71	1.39	.87	2.34
H_2O-	.11	.16	.15	None.	.72	.16	.12
H_2O+	1.05	None.	None.	.62	.62	.32	.32
TiO_2	.34	.98	1.14	1.30	1.54	1.59	.99
P_2O_5	.33	.91	1.26	.50	.45	.42	1.75
MnO	.04	.09	.11	.12	.12	.13	.18
	100.63	100.75	100.62	99.73	100.11	100.27	100.08

CO_2 absent from all.

4. MISCELLANEOUS ROCKS.

A. Obsidian, Obsidian Hill camp, Tewan Mountains. *Liparose*. Described by Iddings, 7th Ann., p. 292. A rhyolitic obsidian, containing grains of iron oxide and a few microscopic feldspars. Resembles that from Obsidian Cliff in the Yellowstone National Park. Analysis by L. G. Eakins, record No. 851. Sp. gr., 2.352, 23.5°.

B. Trachyte (?), from Los Cerrillos. Described by Diller, Bull. 42, p. 39. Analysis by F. W. Clarke, record No. 346. Rock composed chiefly of orthoclase, with a considerable amount of biotite, epidote, pyrite, and limonite, and some amorphous substance. It is the matrix or gangue rock of the Los Cerrillos turquois.

C. Gabbro porphyry, Mount McKensie, Los Cerrillos Mountains. *Andose*. Received from J. F. Kemp. Described by D. W. Johnson, in School of Mines Quart., vol. 25, p. 82. Analysis by George Steiger, record No. 2027. Contains augite, plagioclase, orthoclase, and biotite. P. R. C. 1300.

D. Andesite, country rock, Bonanza mine, Hillsboro. *Shoshonose*. Contains plagioclase, orthoclase, augite, and hornblende.

E. Syenite porphyry, Cooks Peak. *Darose*. Contains orthoclase, plagioclase, biotite, hornblende, and quartz. Rocks D, E, described by C. H. Gordon. Analyses, as yet unpublished, by G. Steiger, record No. 2238. P. R. C. 1921.

F. Quartz syenite, near Merrimac mine, 3 miles east of Organ City, Organ Mountains. Contains orthoclase, albite, quartz, biotite, augite, titanite, and magnetite. Description furnished by W. Lindgren. Analysis by Steiger, No. 2371. P. R. C. 1920.

	A	B	C	D	E	F
SiO_2	76.20	56.68	48.21	54.54	62.95	61.12
Al_2O_3	13.17	16.62	17.96	14.66	15.91	15.78
Fe_2O_3	.34	6.28	5.18	4.20	3.30	2.69
FeO	.73		4.47	2.74	1.37	3.15
MgO	.19	.79	4.11	3.21	2.18	1.90
CaO	.42	.59	9.72	5.64	4.46	3.95
Na_2O	4.31	1.03	3.68	3.47	4.05	4.14
K_2O	4.46	11.18	2.99	5.28	2.95	4.48
H_2O-	.33	3.28	.21	1.10	.72	.32
H_2O+			1.41	1.87	1.19	.56
TiO_2	Trace.	.22	.84	.86	.67	1.30
ZrO_2				None.	None.	.04
CO_2				2.19	None.	.22
P_2O_5		.73	.58	.49	.18	.45
S				.01		.05
FeS_2		2.21				
MnO	.10	1.02	.31	.29	.08	.09
BaO			.07	.07	.03	.07
SrO			Trace.	.05	.03	.04
CuO		Trace.				
	100.25	100.63	99.74	100.67	100.07	100.35

ARIZONA.

1. GLOBE DISTRICT.

Rocks described by F. L. Ransome in P. P. 12. Analyses A, F, by W. F. Hillebrand, record No. 1988. The others by E. T. Allen, record Nos. 1952, 1955.

A. Quartz monzonite, Lost Gulch. *Toscanose.* Contains quartz, plagioclase, microcline, biotite, iron ore, titanite, apatite, and zircon. P. R. C. 1297.

B. Granite porphyry, one-half mile southwest of Hog ranch. *Lassenose.* Contains orthoclase, quartz, oligoclase, biotite, and iron ore. P. R. C. 1293.

C. Granite porphyry, 2 miles south of Schultze ranch. *Lassenose.* Contains orthoclase, quartz, oligoclase, and biotite, with some chlorite, epidote, and iron ore derived from biotite. P. R. C. 1292.

D. Granite, 1 mile west of Schultze ranch. *Lassenose.* Contains oligoclase, quartz, orthoclase, biotite, muscovite, magnetite, apatite, and zircon. P. R. C. 1291.

	A	B	C	D
SiO_2	68.63	68.95	69.35	70.95
Al_2O_3	13.68	15.84	15.71	16.30
Fe_2O_3	2.53	1.14	1.18	1.01
FeO	1.81	.56	.43	.36
MgO	1.10	.24	.36	.23
CaO	2.51	1.96	1.79	1.85
Na_2O	2.94	4.56	4.78	5.16
K_2O	4.04	3.69	3.63	3.34
H_2O-	.70	.86	1.17	.26
H_2O+	.87	1.49	.97	.37
TiO_2	.69	.22	.19	.23
ZrO_2	.01	.01	Trace.	Trace.
P_2O_5	.24	.08	.08	Trace.
SO_3	....	....	....	Trace.
FeS_2	.11	....	....	....
S	....	None.	Trace.	Trace.
Mn	.15	Trace.	Trace.	Trace.
Ba	.05	.07	.07	.04
Sr	Trace.	....	....	....
Li	Trace.	....	....	....
	100.06	99.67	99.71	100.10

E. Biotite dacite, one-fourth mile north of Old Dominion mine. *Toscanose.* Contains plagioclase, sanidine, quartz, biotite, hornblende, apatite, titanite, zircon, magnetite, and glass. P. R. C. 1299.

F. Quartz-mica diorite, Florence stage road 2 miles south of Pinal Peak. *Tonalose.* Contains labradorite, quartz, biotite, microcline, muscovite, titanite, apatite, magnetite, and zircon, with secondary chlorite, epidote, sericite, calcite, and a little hornblende. P. R. C. 1295.

G. Quartz-mica diorite, 2 miles south of Hog ranch, Pinal Mountains. *SR. 3 of vaalase.* Contains labradorite, quartz, biotite, orthoclase, muscovite, magnetite, titanite, apatite, and zircon, with secondary epidote, sericite, and chlorite. P. R. C. 1296.

H. Olivine diabase, 1 mile northwest of Black Peak. *Auvergnose.* Contains plagioclase, augite, olivine, biotite, iron ore, apatite, and titanite. Perfectly fresh. P. R. C. 1298.

	E	F	G	H
SiO_2	68.76	58.74	61.99	49.00
Al_2O_3	15.48	16.02	15.81	16.87
Fe_2O_3	2.50	4.16	3.28	2.09
FeO	.44	3.50	2.69	8.50
MgO	.56	2.18	2.24	6.70
CaO	2.23	5.12	4.62	10.21
Na_2O	3.89	3.26	2.73	2.57
K_2O	3.88	2.39	2.51	.66
H_2O-	.79	.83	.91	.72
H_2O+	.57	1.60	1.99	1.00
TiO_2	.50	1.29	.94	1.11
ZrO_2	.03	.05	.03	.02
P_2O_5	.06	.56	.11	.13
Cl	.03	Undet.	Undet.	.06
MnO	.02	.22	Trace.	.10
BaO	.08	.10	.06	Trace.
SrO	None.	Trace.	Undet.	None.
NiO	None.	Trace?	Undet.	None.
Cr_2O_3	None.	....	Trace.	.02
V_2O_3	....	....	....	Trace.
S	None.	....	Trace.	None.
FeS_2	None.	.11	....	....
Li_2O	....	Trace.	Undet.	Undet.
	99.82	100.13	99.91	99.75

2. RAY DISTRICT.

Rocks collected by F. L. Ransome, who supplies the petrographic data.

A. Quartz monzonite porphyry, east base of Granite Mountain. *Toscanose.* Contains andesine, oligoclase, orthoclase, biotite, some chlorite, apatite, magnetite, and very little pyrite.

B. Diorite porphyry, one-half mile north of Troy. *Lassenose.* Contains plagioclase and hornblende in a crystalline feldspathic groundmass. Also a little biotite, partly chloritized, and some magnetite and apatite.

C. Granodiorite, one-half mile northeast of Troy. *Yellowstonose.* Contains andesine, quartz, orthoclase, biotite, hornblende, titanite, magnetite, and apatite, with a little sericite and chlorite.

D. Quartz diorite, 2 miles northwest of Kelvin. *Tonalose.* Contains plagioclase, quartz, orthoclase, biotite, hornblende, augite, titanite, apatite, and magnetite.

Analyses A, C, by R. C. Wells, record No. 2611. B, by W. T. Schaller, No. 2625. D, by G. Steiger, No. 2627.

	A	B	C	D
SiO_2	70.52	65.30	64.84	60.42
Al_2O_3	15.54	15.92	16.49	17.27
Fe_2O_3	.77	1.37	1.87	2.60
FeO	1.31	2.19	2.28	3.47
MgO	.66	1.59	1.58	2.30
CaO	2.49	3.89	4.54	6.36
Na_2O	3.96	4.01	4.18	3.14
K_2O	3.72	3.08	2.46	2.34
H_2O-	.36	.34	.19	.40
H_2O+	.88	.78	.98	.86
TiO_2	.27	.50	.50	.83
ZrO_2	None.	None.	.01	None.
CO_2	None.	.27	Trace.	None.
P_2O_5	.09	.29	.19	.20
S	Trace.	.20	None.	.05
MnO	.02	.05	.06	.13
BaO	.03	.12	.02	.03
SrO	None.	....	None.	.06
	100.62	99.90	100.19	100.46

E. Pinal schist, one-half mile south of Indian Village. Contains quartz, sericite, biotite, zoisite (?), chlorite, and magnetite.

F. Pinal schist, three-fourths of a mile north of summit of Granite Mountain. Contains quartz, biotite, sericite, plagioclase, magnetite, and zircon.

G. Metallized Pinal schist, "primary ore," Ray mine. Contains quartz, sericite, chlorite, biotite, pyrite, chalcopyrite, pyrrhotite, and zircon.

H. Altered Pinal schist, "primary ore," No. 1 mine, 2,075 level.

I. Altered Pinal schist, enriched ore, No. 1 mine, 1,940 level.

J. Altered Pinal schist, "primary ore," No. 2 mine, 2,190 level.

K. Altered Pinal schist, enriched ore, No. 2 mine, 1,925 sublevel. Rocks G to K are from the mines of the Ray Consolidated Copper Co. Analysis F by G. Steiger, record No. 2627; the others by R. C. Wells, Nos. 2611, 2754. The Fe reported in analyses H to K is extraneous, and came from the local assayer's bucking board.

	E	F	G	H	I	J	K
SiO_2	61.62	72.87	78.91	68.00	68.44	71.05	68.95
Al_2O_3	19.98	12.89	10.76	16.56	15.34	13.49	12.88
Fe_2O_3	3.46	2.40	.87	.79	.36	.45	None.
FeO	2.57	1.76	1.57	1.73	1.33	1.15	1.12
MgO	1.24	.82	1.66	1.04	.21	.41	.34
CaO	.62	1.90	.25	.27	.07	.17	.18
Na_2O	1.78	3.01	.16	.73	.41	.31	.80
K_2O	5.35	3.03	3.44	5.37	5.74	3.80	4.99
Li_2O	Trace.	......	Trace.	......	......	......	......
H_2O-	.21	.26	.20	.64	.24	.31	.13
H_2O+	2.23	.64	1.94	2.36	2.03	1.89	2.24
TiO_2	.56	.66	.27	.51	.54	.47	.43
ZrO_2	......	......	.04	None.	.02	.01	None.
CO_2	......	......	Trace.	None.	......	......	......
P_2O_5	......	.13	.14	.11	.06	.09	.13
SO_3	......	......	......	None.	None.	Trace.	Trace.
MnO	......	.07	.04	.01	None.	None.	None.
BaO	......	......	......	.16	.05	.07	None.
FeS_2	......	......	.15	1.26	2.03	4.84	4.96
$CuFeS_2$	......	......	.11	......	......	......	......
Cu_2S	......	......	......	.80	3.18	.97	2.83
Fe	......	......	......	.29	.09	.32	.56
	99.62	100.44	100.51	100.63	100.14	99.80	100.54

3. MIAMI DISTRICT.

Four samples of Pinal schist, the so-called "primary ore." Collected by F. L. Ransome. Analyses by Chase Palmer, record No. 2717.

A. From 420-foot level, Miami mine.

B. From 570-foot level, Miami mine.

C. From 3,480-foot level of the Scorpion shaft.

D. From 3,350-foot level of the Joe Bush shaft.

	A	B	C	D
SiO_2	70.63	63.04	63.70	66.92
Al_2O_3	14.02	17.82	19.53	19.23
Fe_2O_3	2.73	2.26	3.46	1.09
FeO	.72	.89	1.36	.45
MgO	.70	.58	1.60	.97
CaO	.13	.13	.41	.27
Na_2O	.41	.62	.46	.39
K_2O	4.93	6.58	5.08	5.61
H_2O-	.14	.20	.19	.24
H_2O+	2.41	2.37	3.43	2.45
TiO_2	.61	.85	.65	.58
P_2O_5	.13	.11	.08	.08
S	.78	1.16	.24	.91
MnO	.01	.01	.01	Trace.
Fe in sulphide	.23	.46	.09	.66
Cu	2.05	2.52	.12	.63
	100.63	99.60	100.41	100.48

4. BRADSHAW MOUNTAINS QUADRANGLE.

Analyses by George Steiger, record No. 1996. Petrographic data furnished by C. Palache. Published by Jaggar and Palache in Folio 126.

A. Quartz monzonite porphyry, Battle Flat. *Tonalose.* Contains quartz, orthoclase, oligoclase, green hornblende, and a little apatite and magnetite, with much secondary chlorite and calcite. P. R. C. 1694.

B. Camptonite, Crazy Basin, 2 miles east of Alexandra. *Shoshonose.* Contains brown hornblende, augite, biotite, feldspar, magnetite, and apatite. The feldspar is apparently about equally orthoclase and andesine, but largely altered to sericite and calcite. P. R. C. 1695.

C. Basalt, facies of trachydolerite, headwaters of Little Ash Creek. *Auvergnose.* Contains labradorite, violet augite, olivine, magnetite, and abundant apatite, with secondary serpentine. P. R. C. 1696.

D. Trachydolerite, headwaters of Little Ash Creek. *Akerose.* Contains oligoclase, augite, a little orthoclase and nephelite, ægirite, olivine, and abundant magnetite and apatite. P. R. C. 1697.

E. Zoisite-hornblende diorite, head of Yava Wash. *Kedabekase.* Contains zoisite, about 47 per cent; actinolite, 17 per cent; quartz, orthoclase, albite, chlorite, kaolin, and magnetite. P. R. C. 1698.

	A	B	C	D	E
SiO_2	60.39	43.68	46.74	52.06	45.73
Al_2O_3	13.94	16.91	16.96	15.52	19.45
Fe_2O_3	4.07	5.06	6.44	5.49	5.28
FeO	2.91	4.01	4.13	7.06	3.18
MgO	2.39	4.76	6.18	2.23	6.24
CaO	5.17	8.07	11.90	5.46	13.86
Na_2O	2.68	2.37	3.13	5.24	.64
K_2O	1.88	4.44	.50	2.24	.32
H_2O-	1.11	1.95	1.24	1.00	1.57
H_2O+	2.76	3.39	.89	.59	3.56
TiO_2	.41	1.24	1.04	2.41	.23
CO_2	2.10	3.13	.58	None.	.28
P_2O_5	.07	.72	.56	.32	Trace.
MnO	.08	.07	.23	.12	None.
	99.96	99.80	100.52	99.74	100.34

5. MORENCI DISTRICT.

Rocks collected by Waldemar Lindgren and described in P. P. 43, p. 168. Analyses by W. F. Hillebrand, record No. 1997.

A. Fresh porphyry, Ryerson mine. 100-foot level. *Lassenose.*

B. Altered porphyry, same locality as A.

C. Altered porphyry, chalcocite zone, Humboldt stopes.

D. Surface alteration of altered porphyry, Copper Mountain.

E. Primary silification of porphyry, Ryerson mine.

	A	B	C	D	E
SiO_2	68.04	46.67	64.88	72.78	69.55
Al_2O_3	17.20	20.92	16.41	15.35	16.43
Fe_2O_3	.34	.37	.65	.55	.46
FeO	.67	.36		.10	.11
MgO	1.05	.85	1.12	.89	.62
CaO	2.21	.15	.11	.14	.15
Na_2O	5.33	.16	.12	.36	.17
K_2O	2.65	4.33	4.96	5.00	5.05
H_2O-	.60	.94	.83	1.21	1.00
H_2O+	1.23	5.01	2.74	3.22	2.69
TiO_2	.41	.43	.38	.45	.41
ZrO_2	.01	Trace.	Trace.	Trace.	Trace.
P_2O_5	.12	.15	.12	.05	.05
SO_3	....	.18	.10	.08	.10
MnO	.06	None.	Trace?	None.	None.
BaO	.10	.04	.07	.02	.05
SrO	.03	None.	Trace?	None.	None.
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace?
V_2O_3	Trace.	....	....	....	....
FeS_2	.24	19.18	4.96	.06	3.09
Cu_2S	.02	.24	2.42	....	.07
ZnS	.03	.32?	None.	....	....
MoS_2	None.	.20	None.	....	None.
	100.34	100.50	99.87	100.26	100.00

6. MISCELLANEOUS ROCKS.

A, B, C, D. Mica basalt, Santa Maria Basin. See Iddings, Bull. Phil. Soc. Washington, vol. 12, p. 212. Not fully described. Analyses by W. F. Hillebrand, record No. 1261.

A. *Auvergnose.*

B. C, D. *Monzonose.*

E. Hornblende porphyrite, Sierra Carrizo. *Dacose.* Described by Cross, 14th Ann., p. 165. Contains plagioclase and hornblende, in a groundmass of quartz and orthoclase. Analysis by Hillebrand, No. 1429.

	A	B	C	D	E
SiO_2	49.36	55.35	57.04	57.48	63.18
Al_2O_3	16.35	12.91	13.66	14.09	16.47
Fe_2O_3	2.93	4.67	4.96	5.21	2.36
FeO	8.55	2.06	1.77	1.35	2.28
MgO	7.06	6.29	4.43	3.49	1.33
CaO	10.08	5.77	6.23	6.05	4.77
Na_2O	2.67	2.65	3.08	3.09	4.40
K_2O	.82	4.86	4.95	4.69	2.93
H_2O-	.22	2.67	1.11	1.20	.27
H_2O+	.65	1.18	1.10	1.37	.60
TiO_2	.98	.87	.94	.94	.60
P_2O_5	.30	.58	.63	.65	.28
MnO	.19	.08	.17	.09	.15
NiO, CoO	.05	.05	.07	.08	....
SrO	None.	Trace.	Trace.	Trace.	.09
BaO	.04	.19	.22	.23	.15
Li_2O	None.	Trace.	Trace?	None.	Trace.
	100.25	99.98	100.36	99.92	99.86

F. Typical hypersthene andesite, San Francisco Mountains. *Lassenose.* Not described. Analysis by T. M. Chatard, record No. 270.

G. Recent lava, 2 miles south of Mount Trumbull. *Camptonose.* Not described. Analysis by L. G. Eakins, record No. 1024.

H. Tourmaline-bearing alkali granite, 5 miles northwest of Bisbee. *Liparose.* Contains microperthitic orthoclase, quartz, oligoclase, biotite, tourmaline, muscovite, apatite, zircon, and iron ore. P. R. C. 1395.

I. Granite porphyry, 3¼ miles north of Waco Junction, Bisbee quadrangle. *Bisbose.* Contains quartz, orthoclase, oligoclase, biotite, muscovite, zircon, and iron ore P. R. C. 1396.

Rocks H and I are described by F. L. Ransome in P. P. 21. Analyses by George Steiger, record No. 2034.

	F	G	H	I
SiO_2	64.82	45.30	75.86	76.81
Al_2O_3	18.27	14.95	12.17	10.96
Fe_2O_3	3.48	1.98	.85	1.18
FeO	.56	9.32	.36	.08
MgO	.85	8.29	None.	.14
CaO	2.89	8.87	.62	None.
Na_2O	5.05	4.27	3.60	.26
K_2O	2.67	1.27	5.04	8.50
H_2O-	.20	.85	.27	.48
H_2O+			.72	1.17
TiO_2	.56	2.66	.21	.13
P_2O_5	.23	2.23	Trace.	Trace.
MnO	.20	Trace.	None.	None.
	99.78	99.99	99.70	99.71

Rocks J, K, L, from Mohave County, are described by F. C. Schrader in Bull. 397. Analyses by G. Steiger, record No. 2328.

J. Minette, Champion mine, Cerbat district. *Shoshonose.* Contains andesine, biotite, augite, orthoclase, iron ores, and apatite, with some secondary chlorite. P. R. C. 1764.

K. Trachyte, Goldroad mine. *Omeose.* Contains orthoclase, albite, quartz, iron ores, apatite, and zircon, with secondary serpentine, epidote, and sericite. P. R. C. 1765.

L. Trachyte, Goldroad mine. Contains sanidine, biotite, chlorite, epidote, serpentine, and quartz. P. R. C. 1766.

Rocks M, N were collected by F. L. Ransome, but are as yet undescribed. Analyses by R. C. Wells, record No. 2628.

M. Rhyolite porphyry from near Tombstone. *Lassenose.*

N. Quartz monzonite from near Tombstone. *Amiatose.*

	J	K	L	M	N
SiO_2	49.59	66.46	58.74	68.04	62.33
Al_2O_3	15.30	14.14	15.09	15.82	16.92
Fe_2O_3	5.01	4.07	4.66	2.34	3.95
FeO	4.19	.40	.84	.84	1.24
MgO	4.50	.67	2.75	.80	1.97
CaO	5.51	.78	2.68	3.26	4.48
Na_2O	2.24	1.26	.25	3.93	3.62
K_2O	3.80	9.26	8.05	3.32	3.36
H_2O-	2.98	.78	2.08	.37	.46
H_2O+	3.59	1.28	3.09	.77	.89
TiO_2	1.50	.83	.98	.42	.63
ZrO_2	.05	.05	.02	None.	.02
CO_2	None.	None.	.61	.04	.04
P_2O_5	.94	.25	.40	.15	.17
S	.09	None.	None.	Trace.	.03
MnO	.11	.03	.09	.07	.07
BaO	.21	.06	.07	.06	.10
SrO	.12	.03	.04	.01	.10
Li_2O	....	....	....	Trace.	Trace.
Cu	....	....	....	Trace.	Trace.
	99.73	100.35	100.44	100.24	100.38

NEVADA.

1. TONOPAH DISTRICT.

Rocks A to F, inclusive, represent hornblende andesite and its various alterations. Collected by J. E. Spurr and partly published in P. P. 42. Analyses by George Steiger, record No. 2067.

A. Hornblende andesite, California-Tonopah shaft. The freshest obtainable. *Pantellerose.* Contains andesine, pseudomorphs of chlorite after hornblende, some quartz, pyrite, and apatite. P. R. C. 1768.

B. Hornblende andesite, also relatively fresh. No. 2 shaft. *Kallerudose near pantellerose.* Contains partly altered, striated feldspars, and pseudomorphs of quartz, pyrite, etc., after biotite and hornblende. The rock is partly altered to quartz and muscovite. P. R. C. 1769.

C. Kaolinic alteration of the andesite, from a pit in the saddle between Halifax shaft and the Mizpah mine. Entirely altered to quartz, kaolin, and muscovite. P. R. C. 1770.

D. The andesite, altered to chlorite and calcite; Mizpah shaft, 675 feet down. Contains chlorite, calcite, a little quartz, feldspar, sericite, hematite, zircon, and apatite. P. R. C. 1771.

E. Hornblende andesite, partly altered to orthoclase (?), Mizpah Hill. Ferromagnesian minerals completely decomposed. Some secondary quartz is present. P. R. C. 1772.

F. The andesite altered to quartz and muscovite, Mizpah vein. Little more than quartz and muscovite can be made out. P. R. C. 1773.

	A	B	C	D	E	F
SiO_2	58.47	60.45	71.14	55.60	73.50	72.98
Al_2O_3	16.85	17.78	15.24	16.70	14.13	14.66
Fe_2O_3	2.04	5.86	1.77	2.23	1.51	1.01
FeO	3.12	.25	.26	3.51	.26	.16
MgO	3.84	1.55	.16	2.60	.21	.33
CaO	1.35	1.04	.09	4.27	.12	.18
Na_2O	4.30	3.58	.24	4.08	.24	None.
K_2O	3.14	2.11	6.31	3.17	5.11	6.03
H_2O-	1.10	2.86	.85	.88	1.07	.97
H_2O+	3.59	2.93	2.87	3.06	2.81	2.95
TiO_2	.77	.81	.48	.72	.47	.44
CO_2	.52	None.	None.	2.76	None.	None.
P_2O_5	.35	.28	.05	.28	.09	.16
SO_3	None.	None.	.05	None.	.17	....
S	....	....	.02	None.	.03	....
FeS_2	.49	.06	....	....	....	Undet.
MnO	.26	Undet.	Undet.	Undet.	Undet.	Undet.
BaO	.11	.07	.17	.12	.19	Undet.
F	.12	....	....	....	....	....
	100.42	99.63	99.70	99.98	99.91	99.87

SrO not looked for.

Rocks G to M were also collected by Spurr. Analyses L, M by W. F. Hillebrand, record No. 2087; the others by George Steiger, No. 2088.

G. Early andesite, hanging wall of vein, 300-foot level, Mizpah mine. A more advanced stage of quartz-muscovite alteration than F. P. R. C. 1774.

H. Extreme stage of alteration of andesite to quartz and muscovite, west drift, Mizpah vein. Quartz, with much muscovite. P. R. C. 1775.

I. Augite-biotite andesite, Mizpah extension shaft. Contains phenocrysts of plagioclase and augite, with some alteration to calcite and serpentine. P. R. C. 1776.

J. Pyroxene-biotite andesite, completely decomposed. Montana-Tonopah shaft. Feldspars entirely altered to calcite, sericite, and quartz. Biotite and hornblende altered to chlorite, calcite, quartz, sericite, siderite, and pyrite. P. R. C. 1777.

K. Biotite dacite, north side of Mount Brougher. *Toscanose.* Contains plagioclase, possibly orthoclase, biotite, and a glassy groundmass. P. R. C. 1778.

L. Biotite andesite, Halifax shaft. *Harzose.* Contains plagioclase, biotite, augite, and magnetite. P. R. C. 1779.

M. Biotite-pyroxene andesite, North Star shaft. Entirely altered. Feldspar altered to calcite. Pyrite, siderite, and rutile are present. P. R. C. 1780.

	G	H	I	J	K	L	M
SiO_2	76.25	91.40	43.00	57.51	71.71	56.26	51.64
Al_2O_3	12.84	4.31	16.49	16.55	14.00	16.18	15.58
Fe_2O_3	.54	.77	2.86	3.20	1.06	5.56	.16
FeO	.33	.11	6.31	2.02	.51	1.17	.58
MgO	.56	.18	6.19	2.30	.43	2.78	2.79
CaO	.16	None.	5.69	6.06	2.25	5.07	6.25
Na_2O	.12	.06	.12	2.76	3.21	3.25	.27
K_2O	3.20	1.68	.84	2.81	4.41	3.43	2.46
H_2O-	2.14	.46	3.00	1.45	.44	2.07	2.56
H_2O+	3.17	.98	7.93	2.56	1.38	2.61	4.43
TiO_2	.37	.07	.89	.80	.28	.73	.73
ZrO_2		.02				Trace?	Trace?
CO_2	None.	None.	4.19	1.91	Trace.	.62	4.24
P_2O_5	.12	.04	.36	.30	.07	.32	.31
SO_3		None.	.08	None.	.54	None.	.03
S		None.		.02	None.		
FeS_2			2.55			.03	7.89
NiO						Trace.	None.
MnO		.06		.17		.21	.21
BaO		.02	.07			.12	Undet.
SrO			None.			.06	Trace.
Li_2O						Trace.	(?)
F		Trace.					
	99.80	100.16	100.57	100.42	100.29	100.47	100.13

2. GOLDFIELD DISTRICT.

Rocks described by F. L. Ransome, W. H. Emmons and G. H. Garrey in P. P. 66. Analyses by G. Steiger, record Nos. 2249, 2253, 2339.

A. Altered rhyolite, east slope of Vindicator Mountain. Contains quartz, alunite, calcite, and sericite, with a small amount of undeterminable material. P. R. C. 1691 and 1762.

B. Pyroxene-hornblende andesite, first hill northwest of Vindicator Mountain. *Tonalose.* Contains labradorite, augite, orthorhombic pyroxene, hornblende, magnetite, and apatite, in a glassy base. P. R. C. 1690.

C. Hornblende-pyroxene andesite, 2 miles northeast of Black Butte. *Tonalose.* Contains plagioclase, augite, enstatite or bronzite, hornblende, and magnetite in a glassy groundmass. P. R. C. 1686.

D. Hornblende-biotite andesite, 1 mile northeast of Black Butte. *Amiatose near yellowstonose.* Contains labradorite, hornblende, and biotite in a glassy groundmass with specks of magnetite. P. R. C. 1685.

E. Pyroxene-hornblende andesite, 1 mile northeast of Columbia Mountain. *Andose.* Contains labradorite, augite, hypersthene, magnetite, apatite, and glass. Traces of secondary calcite and chlorite. P. R. C. 1692.

	A	B	C	D	E
SiO_2	75.78	60.41	58.06	63.16	54.66
Al_2O_3	10.65	16.59	17.43	16.74	17.53
Fe_2O_3	.68	3.18	3,83	3.94	3.18
FeO	.16	1.70	1.91	.47	3.52
MgO	None.	2.13	2.60	1.12	3.62
CaO	1.67	5.26	6.33	4.07	7.33
Na_2O	.22	3.94	3.34	3.88	3.56
K_2O	.96	1.70	2.61	3.71	2.22
H_2O-	1.16	1.94	.97	1.12	.59
H_2O+	3.54	2.64	1.88	.77	.69
TiO_2	.12	.62	.87	.61	.99
ZrO_2	.02				
CO_2	.76	None.	None.	None.	1.35
P_2O_5	.02	.31	.27	.30	.30
SO_3	4.73				
BaO	.02				
MnO	None.	.07	.09	.04	.12
	100.49	100.49	100.19	99.93	99.66

F. Dacite, near summit of Diamond Peak. *Harzose near tonalose.* Contains plagioclase, hornblende, augite, biotite, quartz, apatite, magnetite, and glass. P. R. C. 1687.

G. Altered dacite, Combination mine. Contains quartz, kaolin, alunite, and pyrite. P. R. C. 1693.

H. Dacite vitrophyre, 1 mile southwest of Black Cap Mountain. *Amiatose.* Contains labradorite, biotite, and quartz in a glassy base. P. R. C. 1689.

I. Dacite, one-half mile northeast from summit of Columbia Mountain. *Tonalose.* Contains the same minerals as F. P. R. C. 1688.

J. Mica dolerite, 2 miles east of Black Butte. *Hessose-andose.* Contains anorthite, augite, biotite, olivine, magnetite, occasional hornblende, scanty apatite, and a little calcite. The olivine is serpentinized. P. R. C. 1684.

K. Olivine dolerite, mesa above Rabbit Spring. *Hessose.* Contains anorthite and olivine in a groundmass of plagioclase, augite, olivine, magnetite, and apatite. A very little hornblende is also present, with a trace of calcite. The olivine is serpentinized. P. R. C. 1683.

	F	G	H	I	J	K
SiO_2	61.25	60.53	59.99	59.95	48.59	48.20
Al_2O_3	15.92	15.32	16.14	15.77	17.80	21.47
Fe_2O_3	3.75	.20	4.42	3.34	8.70	5.89
FeO	1.17	.14	.13	2.34	.93	2.20
MgO	2.28	.06	1.51	2.73	4.85	3.33
CaO	5.39	.41	4.17	5.84	10.49	10.60
Na_2O	3.19	.84	3.04	3.07	3.06	3.10
K_2O	3.23	1.06	2.82	2.52	1.70	1.33
H_2O-	1.08	1.33	3.35	.95	.76	.96
H_2O+	1.88	6.60	4.06	2.00	.67	1.20
TiO_2	.71	.80	.64	.82	1.54	1.34
ZrO_2		.01		.02		
CO_2	None.	None.	None.	None.	.55	.38
P_2O_5	.22	.27	.24	.26	.43	.39
SO_3		5.97				
F		Trace.		None.		
MnO	.08	Trace.	.05	.09	.14	.11
BaO		.06		.11		
SrO		Undet.		.13		
FeS_2		7.20				
	100.15	100.80	100.56	99.94	100.21	100.50

3. BULLFROG DISTRICT.

Rocks described by Ransome, Emmons, and Garrey in Bulletin 407. Analyses by G. Steiger, record No. 2272.

A. Rhyolite, southeast slope of Bush Peak. *Alaskose*. Contains quartz, orthoclase, albite, oligoclase, biotite, magnetite, and rutile.

B. Rhyolitic glass, west slope of Burton Peak, near summit. *Toscanose*. Contains quartz, orthoclase, oligoclase, biotite, magnetite, hornblende, hypersthene, and augite.

C. Quartz latite, east slope of Black Peak. *Toscanose*. Contains oligoclase, andesine, quartz, biotite, orthoclase, augite, ilmenite, magnetite, titanite, and apatite.

D. Quartz basalt, knob east of summit of Black Peak. *Tonalose*. Contains andesine, oligoclase, quartz, olivine serpentinized, augite, mica, magnetite, and rarely hornblende.

E. Leucite basanite, road to Indian Springs, 1½ miles north of Rhyolite. *Amargose*. Contains augite, olivine, leucite, magnetite, ilmenite, plagioclase, nephelite, biotite, zircon, apatite, and calcite.

	A	B	C	D	E
SiO_2	77.26	71.60	63.34	59.72	43.62
Al_2O_3	11.54	12.44	15.46	14.63	12.73
Fe_2O_3	.85	1.00	4.14	3.40	4.89
FeO	.13	.65	.39	2.37	4.10
MgO	.20	.06	.66	2.69	9.37
CaO	.58	1.90	2.01	6.55	11.62
Na_2O	2.96	3.30	3.89	3.28	2.96
K_2O	4.65	4.22	5.31	3.33	1.30
H_2O-	1.03	.81	1.89	.72	1.91
H_2O+	.96	3.78	1.16	1.38	3.94
TiO_2	.18	.25	1.53	.95	1.46
ZrO_2	....	.01	....	....	.02
CO_2	None.	None.	None.	1.12	.63
P_2O_5	Trace.	.08	.22	.40	.82
MnO	.03	.06	.04	.10	.12
BaO	None.	.03	.15	.04	.16
SrO	None.	.03	.03	Undet.	.14
	100.37	100.22	100.22	100.68	99.79

4. ELY.

Rocks intended to show the alteration and sulphidization of the original monzonite porphyry. Collected by A. C. Spencer but not yet fully described.

A. Fresh monzonite porphyry. *Shoshonose*. Mainly orthoclase and hornblende, with noteworthy labradorite and some quartz. Titanite and albite also present. Analysis by R. C. Wells, record No. 2592.

B. Altered monzonite, Veteran mine. *Kallerudose*. The plagioclase is partly changed to sericite. Also contains biotite, orthoclase, quartz, and pyrite. Analysis by G. Steiger, No. 2595.

C. Oxidized capping over Veteran ore body. Supposed to represent the alteration of metamorphosed limestone.

D. Enriched ore, Veteran mine. Analyses C, D, by Chase Palmer, No. 2600.

	A	B	C	D
SiO_2	57.26	64.11	64.83	79.11
Al_2O_3	17.79	16.52	5.34	3.82
Fe_2O_3	3.39	.41	15.61	.44
FeO	3.45	1.07	.13	.69
MgO	2.02	1.85	.74	1.19
CaO	6.58	1.00	2.27	.62
Na_2O	3.06	1.64	.22	.31
K_2O	4.15	8.26	.24	.54
H_2O-	.53	.58	5.44	.81
H_2O+	.55	1.71	4.18	2.68
TiO_2	.71	.75	.27	.81
ZrO_2		.03		
CO_2	.04	.48		
P_2O_5	.21	.40	.51	.42
F	.04			
Cl	Trace.			
S			.15	
MnO	.29	.01	.72	
BaO	.07	.07		
SrO	Trace.	.04		
FeS_2	.13	.32		.82
$CuFeS_2$		.95		7.42
Cu	Trace.		.19	
	100.27	100.20	100.84	99.68

E. Oxidized capping over ore in metamorphosed limestone, Old Glory mine. Contains magnetite. Analysis by Palmer, No. 2600.

F. Enriched ore, bottom of Copper Flat mine. Original plagioclase destroyed by sericitization. Analysis by Steiger, No. 2595.

G. Ore, west side of Copper Flat mine. Plagioclase replaced by sericite, orthoclase not attacked. Quartz and sulphides added. Analysis by Wells, No. 2592.

H. Ore material after complete oxidation, west side of Copper Flat mine. Composed mainly of quartz and sericite, with some orthoclase and kaolin. Analysis by Wells, No. 2592.

I. Sulphidized monzonite, shaft of Ely Central Co. Analysis by Steiger, No. 2595.

	E	F	G	H	I
SiO_2	65.42	64.73	74.62	80.58	60.37
Al_2O_3	5.41	14.41	10.23	8.51	15.96
Fe_2O_3	15.17	None.		1.15	.51
FeO	.13	.53	.55	Undet.	1.80
MgO	.70	.76	.83	None.	1.63
CaO	2.16	.44	Trace.	.15	4.12
Na_2O	.34	.70	.33	.41	3.13
K_2O	.10	7.84	6.57	5.33	5.07
H_2O-	4.83	.82	.26	.45	.92
H_2O+	3.99	1.94	.69	1.29	1.34
TiO_2	.69	.57	.42	.29	.71
ZrO_2		.04			.04
CO_2	.04	None.		None.	.74
P_2O_5	.51	.10	.06		.47
SO_3		.22			.09
S	.13				
MnO	.74	None.		None.	.05
BaO		.04		.06	.11
SrO		None.			.09
Cu	.13				
FeS_2		1.60	2.32	1.54	3.11
Cu_2S			.98	.13	
$CuFeS_2$		5.77	2.25	.29	.20
	100.49	100.51	100.11	100.18	100.46

5. MISCELLANEOUS ROCKS.

A. Rhyolite, south-southeast of McClellan Peak, Washoe. *Mihalose.* Contains feldspars, orthoclase predominating over plagioclase, quartz, mica, and hornblende.

B. Dacite, spur northeast of McClellan Peak. *Toscanose.* More plagioclase than orthoclase, much mica, less hornblende, little quartz.

Rocks A and B are described by Hague and Iddings in Bull. 17. Analyses by F. A. Gooch, records Nos. 119, 129. FeO not separately determined.

C. Basalt, summit of Richmond Mountain, Eureka. *Hessose.* Red, porous. Contains augite, less hypersthene, feldspars, and magnetite, in a glassy base, with accessory olivine and quartz. Analysis by J. E. Whitfield, record No. 424.

D. Andesitic perlite, south of Carbon Ridge, Eureka. *Amiatose.* Contains plagioclase, hornblende, biotite, quartz, hypersthene, augite, magnetite, apatite, and zircon, with a glassy base. Analysis by W. H. Melville, record No. 1240.

Rocks C and D are described by Hague and Iddings in Mon. XX.

E. Dacite, west side of Silver Peak range, south of Emigrant Road. *Lassenose-toscanose.* Contains phenocrysts of plagioclase, sanidine, possibly quartz, biotite, hornblende, augite, magnetite, and apatite.

F. Spherulitic rhyolite, southeast of Red Mountain, Silver Peak range. *Toscanose.* Contains sanidine, quartz, biotite, titanite, magnetite, and zircon, in a spherulitic groundmass.

Analyses E and F by George Steiger, record No. 1887. Rocks E, F, collected by H. W. Turner. Described in P. P. 55.

	A	B	C	D	E	F
SiO_2	73.07	69.96	50.38	65.13	69.76	72.54
Al_2O_3	11.78	15.79	19.83	15.73	14.05	13.32
Fe_2O_3	2.30	2.50	6.05	2.24	2.05	2.41
FeO			2.00	1.86	None.	.09
MgO	.39	.64	5.36	1.49	.17	.51
CaO	2.02	1.73	10.03	3.62	1.73	1.37
Na_2O	1.19	3.80	2.15	2.93	3.90	3.40
K_2O	6.84	4.12	1.76	3.96	3.57	5.25
H_2O-	[a] 2.24	[a] 1.53	1.37	.52	.62	.21
H_2O+				1.91	3.65	.97
TiO_2	......	......	None.	.58	.19	.35
P_2O_5	......	......	None.	.23	.07	.11
ZrO_2	......	......	......	......	......	.06
NiO	......	......	......	.07	......	......
MnO	......	......	.38	Trace.	.10	None.
BaO	......	......	......	......	.14	.03
Li_2O	......	......	Trace.	......	......	......
SO_3	......	......	.83	......	......	......
	99.83	100.07	100.14	100.27	100.00	100.62

[a] Loss on ignition

The following rocks, G to X, inclusive, were collected by J. E. Spurr, who furnishes the petrographic data.

G. Olivine basalt, Crater, Silver Peak. *Hessose.* Analysis by George Steiger, record No. 1883. Contains plagioclase, olivine, and magnetite in a groundmass of feldspar and olivine. Described by Spurr in P. P. 55. P. R. C. 1907.

H. Hornblende-pyroxene-biotite-quartz latite, Coyote Springs, north end of Pahute Range. *Harzose.* Analysis by W. F. Hillebrand, record No. 1881. Phenocrysts of hornblende, biotite, plagioclase, quartz, and magnetite, in a brown, glassy groundmass. P. R. C. 1903.

I. Biotite-quartz monzonite, Cherry Creek, Egan Range. *Amiatose.* Analysis by H. W. Stokes, record No. 1882. Contains quartz, biotite, and plagioclase. P. R. C. 1895.

J. Quartz-muscovite rock, Belmont. Described by Spurr in Am. Jour. Sci., 4th ser., vol. 10, p. 358. Analysis by Stokes, No. 1882. Contains quartz and muscovite, with some calcite and orthoclase, and a little zircon. P. R. C. 1272.

K. Hornblende-quartz andesite, Masons Butte, Walker River Valley. *Andose.* Described by Spurr, Jour. Geology, vol. 9, p. 593. Analysis by Stokes, record No. 1882. Phenocrysts of feldspar, pale-green hornblende (partly altered to calcite, chlorite, and epidote), and quartz, in a groundmass of feldspar and hornblende, with quartz, pyrite, and siderite. P. R. C. 1897.

L. Hornblende-biotite-quartz diorite, Masons Butte. *Tonalose.* Described by Spurr, as under K. Analysis by Stokes, No. 1882. Contains oligoclase, quartz, hornblende, and biotite. P. R. C. 1896.

	G	H	I	J	K	L
SiO_2	47.09	62.97	67.60	84.15	53.37	60.25
Al_2O_3	18.40	15.52	15.89	9.67	16.57	17.90
Fe_2O_3	2.66	4.03	1.77	.51	3.84	3.08
FeO	5.62	1.45	1.82	.07	2.45	2.44
MgO	7.06	2.07	.96	.04	5.79	2.44
CaO	10.19	5.31	3.38	.53	6.30	5.57
Na_2O	2.37	3.31	3.39	2.65	3.40	4.29
K_2O	1.34	3.46	3.39	1.57	2.55	1.89
H_2O-	.66	.66	.23	.21	.39	.20
H_2O+	2.37	.48	.87	.74	2.23	1.24
TiO_2	1.19	.67	.60	Trace.	.86	.65
ZrO_2	......	Trace.	......	......	......	......
CO_2	None.	.18	None.	None.	1.61	None.
P_2O_5	.54	.18	.19	Trace.	.29	.25
S	.03	Trace.	......	......	......	......
F	......	Undet.	......	.02	......	......
MnO	None.	.10	Trace.	Trace.	.08	.06
SrO	Undet.	.02	Trace.	Trace.	Trace.	.07
BaO	.17	.09	Undet.	Undet.	Undet.	Undet.
Li_2O	......	Trace.	......	......	......	......
	99.69	100.50	100.09	100.16	99.73	100.33

M. Biotite rhyolite, south end of Pine Nut Range. *Lassenose.* Described by Spurr, Jour. Geology, vol. 9, p. 599. Analysis by Stokes, record No. 1882. Contains quartz, orthoclase, and striated feldspars in a microcrystalline groundmass. P. R. C. 1898.

N. Siliceous granite, south end of Pine Nut Range. *Liparose-toscanose.* Description by Spurr and analysis by Stokes as under M. Contains quartz, orthoclase, microcline, anorthoclase, albite, biotite, hornblende, and titanite. P. R. C. 1899.

O. Tordrillite, Cactus Corral, Ralston Desert. *Alaskose-liparose.* Analysis by Steiger, record No. 1883. Consists mainly of quartz and orthoclase. P. R. C. 1909.

P. Tordrillite, Tybo, Hot Creek Range. *SR. 4 of alaskase.* Analysis by Steiger, No. 1883. Contains orthoclase and quartz, with secondary sericite. P. R. C. 1910.

Q. Siliceous rhyolite, west side of Quinn Canyon Range. *Toscanose.* Described by Spurr, Jour. Geology, vol. 9, p. 602. Analysis by Steiger, No. 1883. P. R. C. 1901.

R. Biotite granite, west side of Quinn Canyon Range. *Toscanose.* Description by Spurr and analysis by Steiger as under Q. Contains essential quartz and orthoclase, with accessory hornblende, titanite, magnetite, and a little striated feldspar. P. R. C. 1902.

	M	N	O	P	Q	R
SiO_2	71.49	75.09	75.70	77.84	74.67	71.48
Al_2O_3	15.06	13.51	13.33	13.20	13.25	13.00
Fe_2O_3	1.51	1.13	.40	.80	1.06	1.25
FeO	.88	.08	.06	.25	.18	1.55
MgO	.35	.18	.06	.11	Trace.	.95
CaO	1.54	.91	.55	.20	1.26	2.60
Na_2O	4.19	3.58	3.19	4.06	3.99	2.60
K_2O	3.39	4.71	5.39	1.55	4.62	4.24
H_2O-	.16	.17	.31	.37	.18	.20
H_2O+	.88	.25	1.17	1.21	.22	1.24
TiO_2	.20	.22	.02	None.	.07	.43
CO_2	None.	None.	None.	None.	.79	.30
P_2O_5	.08	.04	.07	.04	.06	.09
Cl	......	......	......	Trace.	......	......
S	......	......	.05	.10	Trace.	None.
MnO	Trace.	Trace.	Trace.	None.	None.	.09
SrO	Trace.	Trace.	Undet.	None.	None.	Undet.
BaO	Undet.	Undet.	.04	None.	None.	.09
	99.73	99.87	100.34	99.73	100.35	100.11

S. Biotite-hornblende-quartz latite, Bullionville, near Pioche. *Amiatose.* Analysis by W. F. Hillebrand, record No. 1881. Contains abundant quartz, plagioclase, biotite, hornblende, and magnetite, in a glassy groundmass. P. R. C. 1906.

T. Biotite rhyolite, Meadow Creek Canyon. *Liparose-toscanose.* Analysis by Hillebrand, No. 1881. Contains quartz, orthoclase, some microcline, and a little biotite, in a glassy groundmass. P. R. C. 1904.

U. Tordrillite, Meadow Creek Canyon. *Liparose.* Analysis by Hillebrand, No. 1881. Contains quartz, orthoclase, and plagioclase, with accessory biotite, in a glassy groundmass. P. R. C. 1908.

V. Tordrillite, Sweetwater. *Toscanose-liparose.* Analysis by George Steiger, record No. 1883. Contains orthoclase and a little anorthoclase, in a feldspathic groundmass. P. R. C. 1900.

	S	T	U	V
SiO_2	63.08	72.96	74.00	74.30
Al_2O_3	15.74	12.32	13.48	13.29
Fe_2O_3	4.94	.76	1.73	1.15
FeO	.42	.03	.06	.10
MgO	1.38	.35	.13	.09
CaO	4.10	2.18	.63	.85
Na_2O	3.16	3.24	4.63	3.75
K_2O	3.39	4.88	5.12	4.83
H_2O-	1.70	.80	.11	.91
H_2O+	.98	1.63	.15	.50
TiO_2	.71	.11	.16	.20
ZrO_2	.02	Trace.	.04	......
CO_2	Trace.	.92	Trace.	None.
P_2O_5	.17	.10	.06	.07
Cl	......	......	......	......
F	......	......	......	......
S	Trace.	None.	Trace.	.03
MnO	.07	Trace.	Trace.	Trace.
SrO	.04	Trace.	None.	Undet.
BaO	.10	Trace.	.05	None.
Li_2O	Trace.	Trace.	Trace.	......
	100.00	100.28	100.35	100.07

W. Quartz-muscovite rock, southern Klondike district. *Near SR. 1 of riesenase.* Analysis by Hillebrand, No. 2087. Consists mainly of quartz and muscovite. P. R. C. 1781.

X. Another sample like W. *SR. 1 of dargase.* Same analyst, number, and description. Rocks W, X, described by Spurr in Econ. Geol., vol. 1, p. 369.

Y. Rhyolite, South Hilltop Tunnel, Jarbidge district, *I. 3. 1. 1.*

Described by F. C. Schrader in Bull. 497. Contains quartz, orthoclase, pyrite, magnetite, and apatite. Analysis by Steiger, record No. 2507. P. R. C. 1856.

Z. Dike rock, near Lovelock mine, Cottonwood Canyon, Churchill County. Collected by F. L. Ransome. Analysis by Steiger, No. 2410. P. R. C. 1813.

	W	X	Y	Z
SiO_2	72.69	75.51	76.77	61.71
Al_2O_3	13.42	14.28	12.63	16.63
Fe_2O_3	.97	1.09	1.13	.40
FeO	.32	.38	.27	
MgO	.26	.28	.07	None.
CaO	1.97	.34	.21	5.94
Na_2O	.21	.20	.30	8.52
K_2O	3.36	4.69	6.43	.16
H_2O-	2.36	[a] 3.36	.49	.51
H_2O+	2.60		1.55	.81
TiO_2	Undet.	Undet.	.18	.79
ZrO_2	....	....	....	.04
CO_2	.97	....	....	4.05
P_2O_5	Undet.	Undet.	.04	.15
MnO	Present.	Trace.	None.	....
Cl	Trace.	Trace.	....	....
F	.25	.20	....	....
Li_2O	....	Trace.	....	....
	99.38	100.33	100.07	99.71
Less O	.10	.08	....	....
	99.28	100.25	....	....

[a] Loss on ignition.

CALIFORNIA.

1. MOUNT SHASTA.

Description of rocks furnished by J. S. Diller, who also described A, B, and C in Bull. 150, pp. 221, 227.

A. Hornblende andesite, Black Butte, west base of Shasta. *Yellowstonose.* Contains plagioclase and hornblende in a microlitic groundmass. The latter carries hypersthene, magnetite, and amorphous matter. Analysis by W. H. Melville, record No. 1346. P. R. C. 84.

B. Hypersthene andesite, older flow, west base of Shasta. *Yellowstonose.* Contains plagioclase, hypersthene, magnetite, and glass. Analysis by Melville, No. 1346. P. R. C. 87.

C. Hypersthene andesite, like B, same locality, later flow. *Tonalose.* Analysis by Melville, No. 1346. P. R. C. 87.

D. Pyroxene andesite, late flow, eastern side of Shasta. *Tonalose.* Contains small crystals of plagioclase and hornblende in a dark groundmass. Thin section not examined. Analysis by H. N. Stokes, record No. 1532. P. R. C. 1415.

E. Plagioclase basalt from near McCloud River, south of Mount Shasta. *Hessose.* A gray cellular rock. Thin section not examined. Analysis by Stokes, No. 1532. P. R. C. 1416.

F. Andesite basalt, Delta, Shasta County. *Beerbachose.* Much plagioclase and a few hypersthene crystals in a groundmass chiefly of feldspar, pyroxene, and magnetite, with a trace of olivine. Analysis by Melville, No. 1346. P. R. C. 1417.

	A	B	C	D	E	F
SiO_2	64.48	64.52	63.03	61.58	47.94	55.08
Al_2O_3	19.28	18.31	17.72	16.96	18.90	18.93
Fe_2O_3	1.40	.90	2.27	1.75	2.21	2.02
FeO	1.78	2.51	1.92	2.85	8.59	5.56
MgO	1.64	2.35	3.63	3.67	8.21	5.17
CaO	5.06	5.11	5.97	6.28	9.86	8.40
Na_2O	4.41	4.64	3.92	3.94	2.81	4.23
K_2O	1.12	1.25	1.06	1.28	.29	.74
H_2O-	.06	.20	.44	.24	.39	.29
H_2O+				1.06	.74	
TiO_2	Undet.	Undet.	Undet.	.49	.57	Trace.
P_2O_5				.22	.15	
MnO				Trace.	Trace.	
SrO				Trace.	None.	
BaO				.03	None.	
Li_2O				Trace.	Trace.	
	99.23	99.79	99.96	100.35	100.66	100.42

The following rocks are from Shasta County but not within either the Mount Shasta or the Lassen Peak areas. Collected by J. S. Diller, who furnishes the petrographic data.

A. **Dacite porphyry, East Fork of Clear Creek, 9 miles above French Gulch.** *Lassenose.* **Contains conspicuous phenocrysts** of plagioclase, a few of quartz, and smaller ones of biotite and pyroxene in a groundmass of quartz and feldspar. Analysis by J. E. Whitfield, record No. 970. P. R. C. 1418.

B. **Dacite porphyry, Smiths Gulch, 6 miles up Clear Creek from French Gulch.** *Yellowstonose.* Contains phenocrysts of plagioclase, quartz, biotite, and hornblende in a groundmass chiefly of quartz and feldspar. Analysis by Whitfield, No. 971. Also described by J. P. Iddings in Bull. 150, p. 233. P. R. C. 90.

C. Diorite, from Ono. *Yellowstonose.* Not described. Analysis by T. M. Chatard, record No. 1107.

D. Metarhyolite. *Tonopose.* The country rock near the Bully Hill mine. Rich in porphyritic quartz.

E. Metabasalt. Country rock, wall of ore body, Bully Hill mine. Porphyritic quartz absent.

Analyses D, E, by E. T. Allen, record No. 1981. The rocks are described by Diller in Bull. 213.

	A	B	C	D	E
SiO_2	66.30	64.24	68.10	81.25	49.85
Al_2O_3	17.55	18.67	15.18	9.03	17.00
Fe_2O_3	2.19	1.40	1.34	.63	4.02
FeO	.55	1.96	1.70	.40	5.51
MgO	.97	1.48	2.06	2.48	7.65
CaO	3.12	4.11	4.66	Trace?	1.18
Na_2O	5.15	4.14	3.71	.25	4.78
K_2O	2.45	1.71	1.48	1.82	None.
H_2O-	1.25	1.18	.55	1.09	2.16
H_2O+				2.81	6.65
TiO_2	Trace.	.76	.35	.08	.97
P_2O_5	.15	.08	.18	Trace.	.10
S				.35	.07
SO_3	.28	.22			
Cl		.25			
MnO	Trace.	Trace.	.20	Trace.	None.
BaO			.06	.05	Trace.
	99.96	100.20	99.57	100.24	99.94
Less O		.05		.13	.13
		100.15		100.11	99.81

The 16 following rocks, from mining districts in Shasta County, were collected by B. S. Butler, who furnishes the mineralogical data. All but 6 of them are technically incomplete.

A. Granite porphyry, Bully Hill district. *Westphalose.* Contains quartz, orthoclase, plagioclase, iron ores, apatite, and sphene. Analysis by G. Steiger, record No. 2378.

B. Altered granite porphyry, Bully Hill. Contains quartz, orthoclase, plagioclase, kaolin, and chlorite. Analysis by Chase Palmer, No. 2379.

C. Granite porphyry, near Shasta King mine. *Westphalose.* Contains quartz, orthoclase, plagioclase, iron ore, apatite, zircon, and sphene. Analysis by Steiger, No. 2378.

D. Altered granite porphyry, near Shasta King mine. Contains quartz, orthoclase, plagioclase, chlorite, and epidote. Analysis by Palmer, No. 2379.

E. Granite porphyry, Afterthought district. *Vulcanose.* Contains quartz, orthoclase, plagioclase, and iron ore. Analysis by Steiger, No. 2378.

F. Granite porphyry, Little Backbone Mountain. *Vulcanose.* Contains quartz, orthoclase, plagioclase, magnetite or ilmenite, apatite, and sphene. Analysis by R. C. Wells, No. 2380.

	A	B	C	D	E	F
SiO_2	78.50	83.73	80.09	76.80	76.52	74.32
Al_2O_3	11.50	9.83	10.80	12.27	12.08	12.08
Fe_2O_3	.11	None.	1.07	.72	.92	.54
FeO	1.82	.64	.83	1.64	.93	1.51
MgO	.46	.04	.58	1.17	None.	.03
CaO	.50	.21	.38	.71	1.21	4.17
Na_2O	6.04	3.52	5.60	4.34	6.19	4.15
K_2O	None.	.61	None.	1.26	None.	.32
H_2O-	.30	.82	.24	.20	.34	.20
H_2O+	.82	.85	.52	1.13	.62	2.31
TiO_2	.27	....	.16	....	.18	.22
ZrO_2	None.	....	.01	....	None.	....
CO_2	None.	None.	None.	.14	.46	None.
P_2O_5	.03	....	.04	....	.06	....
S	.13	....	None.	....	.57	....
MnO	.03	....	.02	....	.03	....
	100.51	100.25	100.34	100.38	100.11	99.85

BaO, SrO, and SO_3 absent.

G. Altered granite porphyry, between Mammoth and Summit mines. Contains quartz, orthoclase, plagioclase, chlorite, epidote, calcite, and sericite. Analysis by Wells, No. 2380.

H. Altered granite porphyry, near Iron Mountain mine. Contains quartz, orthoclase, plagioclase, chlorite, and epidote. Analysis by Palmer, No. 2379.

I. Silicified granite porphyry, near Clipper mine. Contains quartz, feldspar, and sericite. Analysis by Palmer, No. 2379.

J. Monzonite, railroad cut near Spring Creek. *Vulcanose.* Contains quartz, orthoclase, plagioclase, hornblende, iron ore, and apatite. Analysis by Steiger, No. 2378.

K. Inclusion in monzonite. *Bandose.* Contains quartz, orthoclase, plagioclase, iron ore, chlorite, and epidote. Analysis by W. T. Schaller, No. 2377.

	G	H	I	J	K
SiO_2	77.63	72.53	76.47	71.48	62.77
Al_2O_3	12.33	14.90	13.90	13.24	15.04
Fe_2O_3	.42	1.57	.18	.94	4.60
FeO	1.26	1.84	.40	3.30	1.92
MgO	.01	2.56	1.74	1.42	2.30
CaO	.41	.23	.19	3.75	6.76
Na_2O	3.88	.63	4.76	3.84	2.60
K_2O	3.75	1.91	.65	.44	.08
H_2O-	.13	.23	.29	.22	.95
H_2O+	.42	3.62	1.34	1.51	3.01
TiO_2				.32	
CO_2	None.	None.	None.	None.	.23
P_2O_5				.06	
MnO				.06	
	100.24	100.02	99.92	100.57	100.26

L. Diorite dike, near Minnesota mine. Contains quartz, orthoclase, plagioclase, hornblende, iron ore, chlorite, and epidote. Analysis by Schaller, No. 2377.

M. Diorite porphyry, near Uncle Sam mine. Contains quartz, plagioclase, iron ore, chlorite, and epidote. Analysis by Schaller, No. 2377.

N. Diorite dike, near Keswick. *Auvergnose.* Contains hornblende, plagioclase, orthoclase, and iron ore. Analysis by Wells, No. 2380.

O. Diabase, Butcher Creek. *Hessose.* Contains plagioclase, orthoclase, pyroxene, hornblende, and iron ore. Analysis by Wells, No. 2380.

P. Feldspar-epidote rock, dike near Spread Eagle mine. *I. 4. 1. 5.* Contains quartz, orthoclase, plagioclase, biotite, epidote, sphene, apatite, and zircon. Analysis by Steiger, No. 2378.

	L	M	N	O	P
SiO_2	54.15	52.13	47.32	52.65	68.75
Al_2O_3	15.38	18.65	17.00	17.81	16.75
Fe_2O_3	4.25	4.88	3.89	2.08	.48
FeO	7.32	4.42	6.48	6.35	1.72
MgO	4.79	3.29	8.58	5.35	.83
CaO	7.70	10.52	10.01	9.03	.89
Na_2O	1.25	1.55	2.36	2.85	6.95
K_2O	.02	.15	.46	.50	.80
H_2O-	1.02	.65	.34	.21	.84
H_2O+	3.83	3.28	3.23	3.08	1.52
TiO_2					.27
CO_2	.38	.87	Trace.	Trace.	None.
P_2O_5					.16
MnO					.04
BaO					.03
SrO					.03
	100.09	100.39	99.67	99.91	100.06

In this group of analyses, A to P, when not otherwise stated, TiO_2 and P_2O_5 were not separately determined.

2. LASSEN PEAK REGION.

Rocks collected by J. S. Diller, who has furnished the petrographic data. Nearly all are from the area covered by the Lassen Peak atlas sheet of the United States Geological Survey. The quartz basalts have been described by Diller in Bull. 79, and partly in Am. Jour. Sci., 3d ser., vol. 33, p. 49. The analyses are so numerous that it seems best to divide them into subordinate groups.

1. RHYOLITE.

A. Rhyolite, a short distance northwest of Willow Lake, near the Geyser, Plumas County. *Alaskose.* A light-gray rock with occasional phenocrysts of quartz and feldspar in a granular groundmass of the same materials. Analysis by W. F. Hillebrand, record No. 414. P. R. C. 1419.

B. Rhyolite, 2 miles northwest of Deer Creek Meadows, Tehama County. *Tehamose.* Shows many small crystals of quartz, feldspar, and biotite in a spherulitic groundmass. Analysis by Hillebrand, No. 415. P. R. C. 1420.

C. Rhyolite, Slate Creek, west of Deer Creek Meadows. *Tehamose.* Composed wholly of spherulites, some of which include crystals of feldspar or biotite. Analysis by Hillebrand, No. 416. P. R. C. 1421.

D. Rhyolite, summit of Mount Stover, Plumas County. *Toscanose.* Composed almost wholly of spherulites, with a few crystals of feldspar and hornblende. Analysis by Hillebrand, No. 417. P. R. C. 1422.

E. Rhyolite, near Slate Creek, west of Deer Creek Meadows. *Toscanose.* A perlite composed chiefly of little glass balls, with a few spherulites, and crystals of feldspar and biotite. Analysis by Hillebrand, No. 418. P. R. C. 1423.

F. Rhyolite, 1½ miles northeast of Clipper Mills, on tramway to Rock Creek, Shasta County. *Tehamose.* A spherulitic rock containing a few microscopic particles of feldspar and hornblende. Analysis by Hillebrand, No. 678. P. R. C. 1424.

G. Rhyolite tuff, divide between the west fork of Willards Creek and the stage road, in Lassen County. Elevation, 5,800 feet. Composed almost wholly of fine angular particles of clear glass. Analysis by George Steiger, record No. 1427. P. R. C. 1425.

Materials for A to F dried at 110° previous to analysis.

	A	B	C	D	E	F	G
SiO_2	74.24	74.65	73.62	72.40	73.64	74.60	70.01
Al_2O_3	14.50	14.11	14.24	14.81	13.44	13.41	12.61
Fe_2O_3	1.27	1.08	.93	.81	.60	1.28	1.47
FeO	.67	.29	.67	.88	.74	.30	.50
MgO	.25	.20	.33	.47	.26	.26	.72
CaO	.11	.80	1.07	1.94	1.26	1.08	1.06
Na_2O	3.00	2.81	3.25	3.91	3.51	3.38	1.94
K_2O	3.66	4.59	4.28	3.90	4.50	4.50	5.12
H_2O-	....	....	....	....	....	....	2.37
H_2O+	2.04	1.40	1.29	.59	1.99	.85	4.68
TiO_2	.20	.21	.21	.18	.11	.16	....
P_2O_5	.07	Trace.	.02	.03	.06	.03	.04
MnO	.06	.11	.08	.07	.06	.06	Trace.
SrO	Trace.	Trace.	Trace.	.04	.02	None.	....
BaO	.18	.08	.10	.10	.11	.11	....
Li_2O	None.	None.	None.	Trace.	Trace.	Trace.	....
SO_3	.03	....	....	....	....	....	....
	100.28	100.33	100.09	100.13	100.30	100.02	100.52

2. DACITES AND ANDESITES.

A. Gray dacite, Lassen Peak. *Lassenose.* Contains hornblende, biotite, plagioclase, quartz, scarce pyroxene, magnetite, apatite, and a glassy base. Analysis by T. M. Chatard, record No. 111. P. R. C. 82.

B. Secretion in dacite, Lassen Peak. Composed chiefly of plagioclase and hornblende. Analysis by Chatard, No. 110. P. R. C. 1426.

C. Reddish dacite, Lassen Peak. Essentially like A. Analysis by Chatard, No. 110. P. R. C. 1427.

D. Dacite, near the timber line, west base of Lassen Peak. *Lassenose.* Small phenocrysts of plagioclase and hornblende, with a few of quartz, in a reddish-gray groundmass containing much amorphous matter. Analysis by W. F. Hillebrand, record No. 668. P. R. C. 1428.

E. Secretion in D. *Hessose.* Composed essentially of plagioclase and hornblende. Analysis by Hillebrand, No. 669. P. R. C. 1429.

Rocks A, C, D, and E described by Diller in Bull. 150, p. 217.

	A	B	C	D	E
SiO_2	69.51	58.97	68.20	68.32	55.14
Al_2O_3	15.75	18.60	16.98	15.26	19.10
Fe_2O_3	3.34	5.94	3.75	1.66	6.16
FeO	....	....	....	1.26	.54
MgO	2.09	6.89	2.07	1.32	4.23
CaO	1.71	2.84	4.33	3.26	8.36
Na_2O	3.89	3.05	2.98	4.27	3.71
K_2O	3.34	2.24	1.52	2.81	1.04
H_2O	.56	1.35	.44	1.37	.91
TiO_2	....	....	....	.31	.52
P_2O_5	Trace.	Undet.	....	.12	.18
MnO	....	....	....	.04	.11
SrO	....	....	....	Trace.	.07
BaO	....	....	....	.07	Trace.
Li_2O	....	....	....	Trace.	Trace.
	100.19	99.88	100.27	100.07	100.07

F. Dacite, east end of Chaos, northwest base of Lassen Peak. *Lassenose.* The youngest dacite of the region. Contains quartz, feldspar, biotite, and hornblende, embedded in a clear pumiceous glass. Analysis by W. F. Hillebrand, record No. 670. Described by Diller in Bull. 150, p. 218. P. R. C. 1430.

G. Secretion in F. *Hessose.* Consists chiefly of plagioclase and hornblende, with some olivine and clear glass. Analysis by Hillebrand, No. 671. P. R. C. 1431.

H. Dacite (?), west side of old crater rim near the Thumb, at the head of Mill Creek, Shasta County. *Yellowstonose.* Shows phenocrysts of hornblende, plagioclase, and pyroxene, and apparently of quartz, in a gray, microlitic groundmass. Analysis by Hillebrand, No. 674. P. R. C. 1432.

I. Streaked dacite, falls of South Fork of Bear Creek, Shasta County. *Lassenose.* Contains plagioclase with a little sanidine, hornblende, quartz, magnetite, some pyroxene inclusions, and glass base. Analysis by R. B. Riggs, record No. 524. P. R. C. 80. Described by Diller in Bull. 150, p. 213.

J. Dacite tuff, Rice's quarry, 6 miles southeast of Paskenta, Tehama County. Clear glass, with fragments of quartz, feldspar, and hornblende. Analysis by George Steiger, record No. 1427. P. R. C. 1433. Described by Diller in Bull. 470.

J 2. Another sample of J. Analysis by E. T. Allen, record No. 2020. See Diller, Am. Jour. Sci., 4th ser., vol. 15, p. 360. P. R. C. 1434.

	F	G	H	I	J	J_2
SiO_2	68.72	53.35	63.81	68.10	65.78	60.23
Al_2O_3	15.15	19.22	17.07	15.50	14.87	18.64
Fe_2O_3	1.16	3.28	2.11	3.20	1.27	3.81
FeO	1.76	4.48	2.15	None.	1.00	.88
MgO	1.28	4.86	2.28	.10	1.89	1.64
CaO	3.30	9.76	4.97	3.02	2.41	6.04
Na_2O	4.26	2.89	4.08	4.20	2.58	3.87
K_2O	2.78	.99	1.96	3.13	2.71	1.46
H_2O-	....	....	....	....	2.87	.95
H_2O+	.74	.77	1.03	2.72	4.32	1.97
TiO_2	.31	.56	.38	.15	....	.57
ZrO_2	....	....	....	....	....	.01
P_2O_5	.09	.10	.10	.03	.08	.20
MnO	.11	.15	.09	Trace.	Trace.	Trace.
SrO	.03	.03	.03	Trace.	....	.05
BaO	.07	Trace?	.04	.06	....	.11
Cr_2O_3	....	....	....	....	....	Trace.
Li_2O	Trace.	Trace.	Trace.	None.	....	....
	99.76	100.44	100.10	100.21	99.78	100.43

K. Pyroxene andesite, west end of Butte Mountain, Plumas County. *Hessose.* Prominent phenocrysts of pyroxene and minute ones of plagioclase, in a dark groundmass containing much globulitic matter. Analysis by W. F. Hillebrand, record No. 411. P. R. C. 1435.

L. Pyroxene andesite, south base of Burney Butte, Shasta County. *Tonalose.* Numerous small phenocrysts of plagioclase and a few of pyroxene, in a gray groundmass containing much amorphous matter. Analysis by R. B. Riggs, record No. 684. P. R. C. 1436.

M. Hornblende andesite, Tuscan Buttes, 7 miles east of Red Bluff. *Tonalose.* A few small phenocrysts or fragments of hornblende, in a groundmass consisting mainly of plagioclase and gray microlitic matter. Analysis by Hillebrand, No. 412. P. R. C. 1437.

N. Hornblende andesite, near Buntingville, Lassen County. *Lassenose.* A few phenocrysts of hornblende, in a groundmass consisting mainly of small feldspars. Analysis by T. M. Chatard, record No. 413. P. R. C. 1438.

O. Hornblende andesite, northwest summit, head of Burney Creek, Shasta County. *Tonalose.* Inconspicuous plagioclase and, rarely, olivine, in a groundmass of plagioclase and pyroxene. Numerous dark spots are due to altered hornblende. Analysis by Riggs, No. 683. P. R. C. 1439.

Rocks in this group dried at 105° before analysis.

	K	L	M	N	O
SiO_2	55.53	62.44	60.93	67.89	60.04
Al_2O_3	17.63	16.39	18.56	17.29	17.43
Fe_2O_3	2.81	4.66	2.68	2.39	5.39
FeO	3.59	1.00	2.19	.21	.53
MgO	5.85	2.65	2.37	.66	3.51
CaO	8.74	6.22	6.63	3.01	6.65
Na_2O	3.09	3.16	3.79	5.11	4.15
K_2O	.92	2.25	1.33	1.69	1.24
H_2O	1.24	1.02	.90	1.34	.90
TiO_2	.56	.31	.61	.21	.49
P_2O_5	.21	.05	.18	.12	.04
MnO	.08	Trace.	.10	.12	.08
SrO	.06	Trace.	.12	.04	(?)
BaO	.02	.03	.02	.03	.04
Li_2O	None.	Trace.	None.	....	Trace.
SO_3	....	Trace.	....	....	Trace.
	100.33	100.18	100.41	100.11	100.49

P. Hypersthene andesite, 1 mile west of summit on Bidwell's road, Butte County. *Andose.* Rich in small phenocrysts of plagioclase and pyroxene, mostly hypersthene, in a groundmass of the same minerals, with magnetite, and probably some amorphous matter. Analysis by W. F. Hillebrand, record No. 410. P. R. C. 1440.

Q. Hypersthene andesite, old crater at head of Mill Creek. *Andose.* Contains small phenocrysts of plagioclase and hypersthene, in a groundmass of plagioclase, pyroxene, magnetite, etc. Some greenish pseudomorphs suggest former olivine. Analysis by T. M. Chatard, record No. 409. P. R. C. 1441.

R. Hypersthene andesite, 2 miles south of Suppans Mountain, Tehama County. *Tonalose.* Abundant plagioclase and hypersthene, with traces of hornblende, in a microlitic groundmass. Analysis by Hillebrand, No. 672. P. R. C. 1442.

S. Secretion in R. *Bandose.* Composed chiefly of plagioclase and hypersthene, with some quartz and amorphous matter. Analysis by Hillebrand, No. 673. P. R. C. 1443.

T. Hypersthene andesite, west base of Suppans Mountain, near Lassen Peak, Tehama County. *Tonalose.* Contains numerous microscopic crystals of plagioclase and hypersthene, in a microlitic groundmass. Analysis by Hillebrand, No. 676. P. R. C. 1444.

Rocks dried at 100° to 110° before analysis.

	P	Q	R	S	T
SiO_2	55.20	57.11	63.47	57.04	58.08
Al_2O_3	18.68	17.78	16.75	19.11	18.37
Fe_2O_3	3.14	3.54	2.15	4.37	2.92
FeO	4.42	2.74	2.75	2.48	3.38
MgO	4.59	3.41	3.04	3.94	3.35
CaO	8.02	7.21	5.72	7.34	7.05
Na_2O	3.66	3.81	3.94	3.48	3.66
K_2O	1.01	1.86	1.62	1.16	1.33
H_2O	.51	.98	.55	1.09	1.09
TiO_2	.92	.95	.37	.47	.44
P_2O_5	.24	.26	.13	.08	.16
MnO	.14	.33	.09	.12	.13
SrO	.02	Trace?	.04	.02	.02
BaO	.03	.03	.04	Trace?	.03
Li_2O	None.	....	Trace.	Trace.	Trace.
	100.58	100.01	100.66	100.70	100.01

U. Hypersthene andesite, 1 mile southwest of Thumb, head of Bailey Creek, near Lassen Peak. *Tonalose.* Abundant but inconspicuous plagioclase and hypersthene, in a microlitic groundmass containing many small crystals of plagioclase. Analysis by W. F. Hillebrand, record No. 675. P. R. C. 1445.

V. Hypersthene andesite, west summit of Crater Peak, Shasta County. *Yellowstonose.* Microphenocrysts of feldspar and hypersthene in a groundmass consisting largely of the same minerals, with some amorphous matter. Analysis by Hillebrand, No. 679. P. R. C. 1446.

W. Hypersthene andesite, north slope of Crater Peak. *Tonalose.* Phenocrysts of plagioclase and hypersthene in a groundmass containing much dark amorphous matter. Analysis by Hillebrand, No. 680. P. R. C. 1447.

X. Secretion in W. *Hessose.* Composed chiefly of plagioclase, hypersthene, and a globulitic base. Analysis by Hillebrand, No. 681. P. R. C. 1448.

Y. Andesitic tuff, Stillwater Creek, 8 miles northeast of Redding. Contains plagioclase, hornblende, rare hypersthene, magnetite, and glass. Fragments of andesite are inclosed. Analysis by W. H. Melville, record No. 1346. Described by Diller in Bull. 150, p. 211. P. R. C. 79.

Rocks dried at 100° to 110° before analysis.

	U	V	W	X	Y
SiO_2	59.84	68.12	61.17	53.85	69.51
Al_2O_3	16.81	16.24	17.74	18.53	15.61
Fe_2O_3	1.88	1.26	1.78	1.96	.56
FeO	3.60	2.08	3.51	5.30	1.27
MgO	3.85	1.35	2.76	5.88	.61
CaO	6.30	3.80	5.90	9.66	2.80
Na_2O	3.63	3.89	3.79	2.98	3.43
K_2O	2.13	2.54	1.71	.74	2.81
H_2O	1.04	.40	.83	.45	3.63
TiO_2	.57	.25	.45	.50	Trace.
P_2O_5	.19	.14	.14	.05	....
Cr_2O_3	Trace?	None.	None.	Trace.	....
MnO	.14	.10	.12	.12	....
SrO	.02	.02	.04	.04	....
BaO	.07	.09	.06	.03	....
Li_2O	Trace.	Trace.	Trace.	Trace.	....
	100.07	100.28	100.00	100.09	100.23

3. BASALTS.

The quartz basalts are described by Diller in Bull. 79. That from Mitylene was analyzed for comparison with the Cinder Cone series.

A. Quartz basalt, Cinder Cone, 10 miles northeast of Lassen Peak. *Andose.* Contains plagioclase, pyroxene (mostly hypersthene), olivine, quartz, and much unindividualized base; the latter about 25 per cent. Magnetite is also present; augite occurs sparingly. Analysis by W. F. Hillebrand, record No. 407. P. R. C. 101. Also described in Bull. 150, p. 252.

B. Volcanic bomb from quartz basalt, Cinder Cone. *Andose.* Analysis by Hillebrand, No. 665. P. R. C. 1449.

C. Lapilli from quartz basalt, Cinder Cone. *Andose.* Analysis by Hillebrand, No. 667. P. R. C. 96. Also described in Bull. 150, p. 249. P. R. C. 791.

D. Volcanic sand, one-half mile northeast of Cinder Cone. *Andose.* Analysis by Hillebrand, No. 663. P. R. C. 792.

E. White pumiceous inclosure from quartz basalt, Cinder Cone. *Alsbachose.* Analysis by Hillebrand, No. 664. Mainly glass. P. R. C. 793.

Rocks dried at 100° to 110° before analysis.

	A	B	C	D	E
SiO_2	57.25	56.70	56.53	55.93	79.49
Al_2O_3	16.45	15.75	17.50	17.34	11.60
Fe_2O_3	1.67	1.29	1.35	1.50	.33
FeO	4.72	5.32	5.03	5.20	.49
MgO	6.74	7.16	5.94	7.29	.09
CaO	7.65	7.67	8.07	8.04	1.64
Na_2O	3.00	3.36	3.51	3.32	4.04
K_2O	1.57	1.56	1.55	1.35	1.52
H_2O	.40	.30	.27	.26	.68
TiO_2	.60	.65	.54	Undet.	Undet.
P_2O_5	.20	.20	.15	Undet.	Undet.
Cr_2O_3	....	Trace.	Trace.	....	....
MnO	.10	.19	.12	Undet.	None.
SrO	Trace.	Trace.	Trace?	(?)	(?)
BaO	.03	.03	Trace.	(?)	(?)
Li_2O	None.	Trace.	Trace.	(?)	(?)
	100.38	100.18	100.56	100.23	99.88

F. Quartz basalt, one-half mile south of Cinder Cone, on border of lava field. *Camptonose.* Analysis by Hillebrand, No. 666. P. R. C. 794.

G. Quartz basalt, west end of Lake Bidwell, on border of Cinder Cone lava field. *Andose.* Contains a few grains of quartz, much olivine and plagioclase, less pyroxene, and a globulitic base. Analysis by Hillebrand, No. 661. P. R. C. 795.

H. Quartz basalt, Silver Lake, near Lassen Peak. *Andose.* Contains occasional grains of quartz, much feldspar and olivine, less pyroxene, and a brownish base. Analysis by Hillebrand, No. 662. P. R. C. 790.

I. Quartz basalt, resting on dacite, near west base of Lassen Peak. *Bandose.* Analysis by Hillebrand, No. 677. P. R. C. 796.

J. Quartz basalt, island of Mitylene, coast of Asia Minor. *Tonalose.* Analysis for comparison with the Cinder Cone series, by T. M. Chatard, record No. 845.

Rocks F to I dried at 100° to 110° before analysis.

	F	G	H	I	J
SiO_2	54.56	56.18	57.59	56.51	56.58
Al_2O_3	16.04	16.59	16.49	18.10	14.88
Fe_2O_3	.95	1.51	1.22	4.26	2.31
FeO	6.07	5.51	4.89	2.68	3.04
MgO	8.71	7.26	7.72	4.52	3.76
CaO	8.89	7.64	7.40	8.15	8.69
Na_2O	3.05	3.58	3.62	3.23	3.36
K_2O	1.18	1.47	.99	1.15	2.18
H_2O-	....	....	....	....	.69
H_2O+	.28	.42	.86	.69	1.43
TiO_2	.53	Undet.	Undet.	.48	.77
P_2O_5	.18	Undet.	Undet.	.14	.15
Cr_2O_3	Trace.	....	....	Trace.	Trace?
MnO	.17	Undet.	Undet.	.11	.16
SrO	Trace.	(?)	(?)	.04	....
BaO	.03	(?)	(?)	.04	.07
Li_2O	Trace.	(?)	(?)	Trace.	....
CO_2	....	....	....	....	2.32
	100.64	100.16	100.78	100.10	100.39

K. Recent basalt, Pit River. Rich in feldspar and augite, poor in olivine. Partial analysis by F. W. Clarke, record No. 109.

L. Basalt, 1 mile southeast of Paynes Creek, on the road from Red Bluff to Lassen Peak. *Auvergnose.* A normal basalt, rather rich in olivine. Analysis by T. M. Chatard, record No. 405. P. R. C. 1242.

M. Basalt, summit of Inskip Crater, 25 miles east of Red Bluff. *Auvergnose.* Mainly feldspar and augite, with a few phenocrysts of olivine. Analysis by Hillebrand and Chatard, record No. 406. P. R. C. 1450.

N. Basalt from the cone at south base of Burney Butte, Shasta County. *Andose.* Composed of plagioclase and augite, with some olivine and a globulitic base. Analysis by R. B. Riggs, record No. 685. P. R. C. 1451.

O. Basalt, near east end of rim of Crater Peak, Shasta County. *Hessose.* Contains plagioclase and pyroxene, some of the latter being hypersthene, with a trace of olivine. Analysis by R. B. Riggs, record No. 682. P. R. C. 1452.

P. Hornblende basalt, Kosk Creek near its mouth, by the great bend of Pit River, Shasta County. *Auvergnose.* Contains abundant phenocrysts of hornblende, with a few of plagioclase, pyroxene, and olivine, in a groundmass of plagioclase, augite, and magnetite. The hornblendes are deeply corroded, and some have disappeared, leaving groups of magnetite grains to mark their former presence. Analysis by L. G. Eakins, record No. 1022. Described by Diller in Am. Geologist, vol. 19, p. 253. P. R. C. 1453.

Rocks dried at 105° to 110° before analysis, except in the case of the rock marked L.

	K	L	M	N	O	P
SiO_2	51.92	47.93	50.89	52.63	52.95	44.77
Al_2O_3	19.76	18.51	16.76	17.62	18.25	17.82
Fe_2O_3	11.21	2.07	3.86	6.49	4.36	5.05
FeO		7.25	4.69	3.10	4.19	6.95
MgO	3.38	9.03	8.49	5.64	4.93	8.22
CaO	9.30	11.14	11.72	8.62	8.73	10.36
Na_2O	2.16	2.28	2.61	3.38	3.57	2.13
K_2O	.60	.24	.32	1.73	.77	.92
H_2O	1.54	.76	.41	.79	1.47	2.64
TiO_2		.73	.79	.07	.66	.53
P_2O_5		.11	.09	.47	Trace.	.72
MnO		.20	.13	Trace.	.12	Trace.
SrO				Trace.	Trace.	
BaO			Trace.	.04	.01	
Li_2O				Trace.	(?)	
CO_2		None.				
SO_3				Trace.	Trace.	
	99.87	100.25	100.76	100.58	100.01	100.11

3. PLUMAS COUNTY.

Some rocks from this county are described under the heading of the Lassen Peak area. The following rocks, with two exceptions, were collected by H. W. Turner, who supplies the descriptions:

A. Granite, dike in serpentine, south slope of Grizzly Hill. *Near alaskose.* Described by Turner in Am. Geologist, vol. 17, p. 375. Contains quartz, albite, and muscovite. Analysis by H. N. Stokes, record No. 1562. P. R. C. 757.

B. Metarhyolite, near Tower Rock, Grizzly Mountains. *Toscanose.* Described by Turner in 14th Ann., p. 441. Contains porphyritic quartz, feldspar, and pyrite, in a fine groundmass. Analysis by W. F. Hillebrand, record No. 1273. P. R. C. 741.

C. Dacite, near Greenville. *Yukonose.* Collected by Diller, who finds phenocrysts of quartz in a groundmass chiefly of quartz and feldspar. Analysis by Hillebrand, record No. 1458. P. R. C. 1454.

D. Granodiorite, southwest base of Mount Ingalls. *Yellowstonose.* Description supplied by Turner. Contains plagioclase, quartz, orthoclase, brown mica, green hornblende, iron oxide, and a little apatite, sphene, and epidote. Analysis by Hillebrand, record No. 1456. P. R. C. 727.

E. Granodiorite, Spanish Peak. *Tonalose.* Description supplied by Turner. Contains plagioclase, quartz, orthoclase, biotite, hornblende, iron ore, and apatite; also abundant secondary epidote and chlorite. Analysis by Stokes, record No. 1562. P. R. C. 756.

	A	B	C	D	E
SiO_2	76.00	73.25	72.77	67.33	59.68
Al_2O_3	14.88	13.25	13.00	15.93	17.09
Fe_2O_3	.65	....	1.28	1.90	2.85
FeO	.10	1.74	2.65	1.59	2.75
MgO	.06	.28	.67	1.63	3.54
CaO	.19	2.23	2.47	4.09	6.62
Na_2O	3.52	2.69	4.95	3.76	3.87
K_2O	2.77	3.79	.34	2.46	1.31
H_2O-	.20	.07	.07	.19	.15
H_2O+	1.42	1.03	1.16	.66	1.00
TiO_2	.04	Trace.	.22	.36	.65
P_2O_5	.11	Trace.	.04	.11	.25
MnO	Trace.	Trace.	.08	.09	Trace.
SrO	....	Trace?	Trace.	Trace.	Trace.
BaO	Trace.	Trace.	Trace.	.08	.04
Li_2O	....	Trace.	Trace.	Trace.	Trace.
CO_2	....	1.05	.47	....	.20
SO_3	Trace.	....	....	....	Trace.
Cl	Trace.	....	....	....	.03
F	Trace.	....	....	....	....
FeS_2	....	.58	....	....	....
	99.94	99.96	100.17	100.18	100.03

F. Rhyolite, 3½ miles southwest of Grizzly Peak. *Toscanose.* Description furnished by Turner. Contains sanidine, with less quartz and biotite, in a glassy ground mass. Analysis by Hillebrand, record No. 1461. P. R. C. 776.

G. Hornblende andesite, 4 miles from Pilot Peak. *Tonalose.* Described by Turner in 14th Ann., p. 441. Contains plagioclase and hornblende in a groundmass carrying grains of magnetite. Analysis by Hillebrand, record No. 1432. P. R. C. 716.

H. Hornblende-pyroxene andesite, southwest base of Mount Ingalls. *Tonalose.* Description supplied by Turner. Contains plagioclase, rhombic pyroxene, augite, brown hornblende, and magnetite, with much glass in the groundmass. Analysis by Hillebrand, record No. 1456. P. R. C. 728.

I. Hypersthene andesite, Franklin Hill. *Hessose.* Description supplied by Turner. Contains plagioclase, rhombic pyroxene, augite, and magnetite. Probably no glass. Analysis by Hillebrand, record No. 1548. P. R. C. 754.

	F	G	H	I
SiO_2	71.39	60.20	58.47	56.88
Al_2O_3	14.13	17.21	18.80	18.25
Fe_2O_3	.63	3.12	3.34	2.35
FeO	.37	2.69	2.64	4.45
MgO	.08	3.18	2.69	4.07
CaO	1.01	6.04	6.60	7.53
Na_2O	2.89	3.35	3.58	3.29
K_2O	5.69	1.44	2.01	1.42
H_2O-	.42	1.12	.14	.24
H_2O+	3.32	1.18	.92	.50
TiO_2	.17	.57	.51	.45
P_2O_5	.03	.17	.22	.30
MnO	Trace.	.12	.13	.18
SrO	Trace.	Trace.	.05	.04
BaO	.09	.11	.09	.11
Li_2O	Trace.	Trace.	Trace.	Trace.
	100.22	100.50	100.19	100.06

J. **Dolerite**, Mount Ingalls. *Hessose*. Described by Turner in 14th Ann., p. 441. Contains plagioclase, augite, hypersthene, magnetite, and a few olivines. Analysis by W. F. Hillebrand, record No. 1273. P. R. C. 739.

K. Dolerite, Mount Ingalls. *Hessose*. Also in 14th Ann., p. 441. Like J but with scarcely any olivine. Analysis by Hillebrand, record No. 1432. P. R. C. 740.

L. Basalt, 4 miles southeast of Mount Ingalls. *Andose*. Also in 14th Ann., p. 441. Contains plagioclase, olivine, augite, and magnetite. Analysis by Hillebrand, record No. 1273.

M. Olivine basalt, 1½ miles from Franklin Hill. *Hessose*. Contains plagioclase, augite, partly altered olivine, magnetite, and probably some glass. Description supplied by Turner. Analysis by George Steiger, record No. 1596. P. R. C. 755.

N. Serpentine, Greenville. Described by Diller in Bull. 150, p. 372. Besides serpentine, the rock contains some magnetite and less chromite, with remnants of the pyroxene from which the serpentine was in great part derived. Analysis by W. H. Melville, record No. 1346. P. R. C. 145.

	J	K	L	M	N
SiO_2	53.91	52.81	50.56	51.21	39.14
Al_2O_3	17.95	16.60	14.71	17.59	2.08
Fe_2O_3	2.21	2.66	3.54	4.71	4.27
FeO	4.80	6.13	8.90	4.42	2.04
MgO	5.52	6.12	4.07	7.12	39.84
CaO	10.40	10.14	7.58	10.36	Trace.
Na_2O	2.90	2.79	2.94	2.49	....
K_2O	1.34	1.05	2.10	.91	....
H_2O-	.20	.38	1.06	.58	12.70
H_2O+	.20	.54	1.12	1.07	
TiO_2	.52	.84	1.71	.31	....
P_2O_5	.21	.23	1.14	.09	....
MnO	.10	Undet.	.13	Trace.	....
SrO	Trace.	Trace.	Trace?	....	....
BaO	.05	.03	.25	None.	....
Li_2O	Trace.	Trace.	Trace?	None.	....
Chromite	....	....	....	....	.11
	100.31	100.32	99.81	100.86	100.18

4. BUTTE COUNTY.

Rocks from this county are also to be found under the heading of the Lassen Peak region. The following rocks were collected by H. W. Turner, to whom the petrographic data are due. Analyses, with two exceptions, by W. F. Hillebrand, record Nos. 1432, 1456, 1461, and 1548. Analysis G is by H. N. Stokes, record No. 1562.

A. Granodiorite, north side of south fork of Feather River, opposite Enterprise. *Lassenose*. Described in 14th Ann., p. 441. Contains plagioclase, potash feldspar, quartz, hornblende, brown mica, and accessory minerals. The ferromagnesian minerals are largely altered to chlorite. P. R. C. 720.

B. Granodiorite, 2 miles east of Bangor. *Tonalose*. Composition like A. The mica is largely altered to chlorite. See 14th Ann., p. 441. P. R. C. 717.

C. Diorite, South Honcut Creek. *Beerbachose*. Description supplied by Turner. Contains feldspar, probably all plagioclase, brown hornblende, and a little chlorite. P. R. C. 775.

D. Quartz diorite, 4.6 miles south of Table Mountain, on ridge between Butte and Plumas counties. *Camptonose*. Described in 17th Ann., pt. 1, p. 521. Contains hornblende, feldspar, quartz, rutile, and a little secondary chlorite and epidote. P. R. C. 758.

E. Amphibole, separated from D. Analysis by William Valentine, record No. 1723. Cr_2O_3 determination by Hillebrand.

	A	B	C	D	E
SiO_2	70.36	63.43	57.87	54.64	50.08
Al_2O_3	15.47	14.20	16.30	12.06	7.97
Fe_2O_3	.98	1.54	1.71	1.81	2.69
FeO	1.17	4.56	3.86	5.03	6.71
MgO	.87	2.35	5.50	11.86	16.31
CaO	3.18	5.51	5.53	7.74	11.21
Na_2O	4.91	3.49	5.01	2.35	1.22
K_2O	1.71	2.19	.75	1.01	.46
H_2O-	.06	.15	.26	.12	....
H_2O+	1.00	1.50	2.40	2.44	1.40
TiO_2	.20	.73	.53	.61	.76
P_2O_5	.11	.11	.27	.08	Trace.
V_2O_3	....	....	....	.03	....
Cr_2O_3	....	....	....	....	.16
NiO	....	....	....	.05	....
MnO	Trace.	.03	.08	.13	.49
SrO	Trace.	Trace.	Trace.	Trace.	....
BaO	.06	.06	.05	.05	None.
Li_2O	Trace.	None.	Trace.	Trace.	....
	100.08	99.85	100.12	100.01	100.46

F. Meta-andesite tuff. Described in 14th Ann., p. 441. Contains plagioclase, augite, epidote, chlorite, and secondary hornblende. P. R. C. 719.

G. Uralite diorite, 1 mile southeast of Forbestown. *Ornose.* Described in 17th Ann., pt. 1, p. 521. Contains plagioclase, hornblende, and magnetite. P. R. C. 751.

H. Basalt, Oroville, Table Mountain. *Camptonose.* Described in 14th Ann., p. 441. Contains plagioclase, olivine, augite, and magnetite. P. R. C. 718.

I. Altered peridotite, 5 miles northeast of Strawberry Valley. Largely serpentine, with olivine, hornblende, magnetite, and calcite or dolomite. P. R. C. 742.

	F	G	H	I
SiO_2	54.66	51.07	50.66	44.81
Al_2O_3	15.85	14.93	13.97	[a] 1.88
Fe_2O_3	1.82	6.44	2.55	1.98
FeO	5.12	5.98	10.20	4.52
MgO	5.64	4.84	4.45	30.91
CaO	8.75	7.89	8.08	6.58
Na_2O	3.46	5.04	3.32	.15
K_2O	.47	.16	1.95	
H_2O-	.25	.24	.27	.15
H_2O+	2.48	1.73	.43	6.88
TiO_2	.67	1.65	2.39	....
P_2O_5	.15	.19	1.01	.02
Cr_2O_3	....	....	....	.29
MnO	.18	.22	.29	.13
NiO	Trace?	....	Trace.	.09
SrO	Trace.	....	Trace.	None.
BaO	.04	....	.22	None.
Li_2O	None.	....	None.	....
CO_2	.39	....	....	1.79
Cl	....	Trace.	.02	....
F	....	Trace.	....	....
SO_3	....	Trace.	....	....
FeS_2	.09	....	....	....
	100.02	100.38	99.81	100.18

[a] Includes possible TiO_2.

5. SIERRA COUNTY.

Rocks collected and described by H. W. Turner. See paper in 17th Ann., pt. 1, p. 521. Additional details supplied by Turner are given here. Analyses A to H by W. F. Hillebrand, record Nos. 1456 and 1548. Analysis I by H. N. Stokes, record No. 1514.

A. Granulite (aplite), Yuba Gap, road east of Sierra Buttes. *Toscanose.* Contains orthoclase, microcline, quartz, plagioclase, some shreds of greenish mica, and a little iron ore, chlorite, and apatite. P. R. C. 730.

B. Granulite (aplite), dike east of Milton. *Toscanose*. Contains orthoclase, quartz, plagioclase, a little microcline, brown mica, and iron ore. P. R. C. 734.

C. Biotite-quartz monzonite, Indian Valley. *Lassenose*. Contains plagioclase, orthoclase, quartz, brown mica, apatite, and iron ore. P. R. C. 737.

D. Quartz diorite porphyry, dike in Indian Valley granite. *Yellowstonose*. Contains plagioclase, hornblende, biotite, and quartz. P. R. C. 738.

E. Quartz-mica diorite, large area east of Milton. *Harzose*. Contains plagioclase, a turbid feldspar which is apparently not orthoclase, quartz, green hornblende, brown mica, iron ore, and apatite. P. R. C. 732.

	A	B	C	D	E
SiO_2	76.03	75.97	68.65	66.65	57.26
Al_2O_3	13.39	13.07	16.34	17.61	16.51
Fe_2O_3	.48	.61	.93	.93	3.27
FeO	.31	.39	1.48	1.67	5.19
MgO	.05	.14	1.29	1.26	3.41
CaO	1.28	1.49	3.07	4.44	6.69
Na_2O	2.98	2.51	4.85	4.59	2.65
K_2O	5.18	5.62	1.85	1.70	2.93
H_2O-	.15	.14	.24	.03	.20
H_2O+	.34	.24	.62	.41	.95
TiO_2	.07	.09	.28	.03	.53
P_2O_5	.03	Trace.	.15	.18	.30
MnO	Trace.	Trace.	.08	.07	.18
SrO	Trace.	.03	.07	....	.06
BaO	.04	.14	.09	.12	.10
Li_2O	None.	Trace.	Trace.	Trace.	Trace.
	100.33	100.44	99.99	99.99	100.23

F. Diabase porphyry, dike east of Milton. *Camptonose*. Contains labradorite and other plagioclase, augite, and hornblende, the last mineral being perhaps secondary. P. R. C. 733.

G. Hypersthene andesite, point northeast of Goodyears Bar. *Yellowstonose*. Contains plagioclase and rhombic pyroxene, a little augite, and scales which seem to represent former biotite, now replaced by magnetite. P. R. C. 731.

H. Hornblende-pyroxene andesite, dike southeast of Poker Flat. *Tonalose*. Contains plagioclase, augite, hornblende, magnetite, some glass, and occasional quartz. P. R. C. 736.

I. Quartz-bearing andesite, northwest of Downieville. *Tonalose*. Contains plagioclase, augite, enstatite, magnetite, occasional quartz, and probably glass. P. R. C. 753.

	F	G	H	I
SiO_2	51.27	66.94	59.34	60.02
Al_2O_3	12.14	16.49	17.61	16.07
Fe_2O_3	2.51	1.41	3.63	2.17
FeO	6.71	1.87	2.28	3.46
MgO	10.88	1.98	3.50	4.57
CaO	10.32	4.77	6.45	7.01
Na_2O	2.00	3.88	3.40	3.55
K_2O	1.63	1.65	1.94	1.59
H_2O-	.17	.35	.64	.24
H_2O+	1.16	.22	.74	.45
TiO_2	.60	.30	.32	.42
P_2O_5	.21	.12	.25	.17
Cr_2O_3	....	....	....	Trace.
NiO	.04	....	....	....
MnO	.21	.13	.12	.10
SrO	Trace?	.05	.04	Trace.
BaO	.07	.07	.11	.08
Li_2O	Trace.	Trace.	Trace.	None.
SO_3	....	....	....	.06
	99.92	100.23	100.37	99.96

8. NEVADA CITY AND GRASS VALLEY.

Rocks of a mining district in Nevada County, described by Lindgren in 17th Ann., pt. 2, p. 1.

A. Granodiorite, 1 mile southeast of Nevada City. *Yellowstonose.* Contains hornblende, biotite, quartz, plagioclase, orthoclase, magnetite, apatite, sphene, and pyrite. Analysis by W. F. Hillebrand, record No. 1478. P. R. C. 1521.

B. Granodiorite, Kate Hayes Hill, Grass Valley. *Harzose.* Contains plagioclase, orthoclase, quartz, hornblende, pyrite, magnetite, apatite, sphene, and zircon. Analysis by Hillebrand, No. 1478.

C. Hornblende porphyrite, Nevada City. *Tonalose.* Contains feldspar, hornblende, quartz, epidote, sericite, and biotite. Analysis by H. N. Stokes, record No. 1531.

D. Quartz porphyrite, New Ophir claim, Grass Valley. *Tonalose.* Contains plagioclase, quartz, uralite, epidote, and augite, and hornblende altered into chlorite. Analysis by Stokes, No. 1531.

E. Diabase, near Maryland mine, Grass Valley. *Ornose.* Contains feldspar, augite, hornblende, ilmenite, pyrrhotite, pyrite, and some chlorite. Analysis by Stokes, No. 1522.

F. Diabase, Grass Valley. *Bandose.* Contains feldspar, pyroxene, hornblende, ilmenite, pyrrhotite, pyrite, and chlorite, and probably a little quartz. Analysis by Stokes, No. 1522.

	A	B	C	D	E	F
SiO_2	66.65	63.85	62.09	63.39	51.01	53.19
Al_2O_3	16.15	15.84	16.69	16.58	11.89	17.12
Fe_2O_3	1.52	1.91	1.45	1.41	1.57	4.35
FeO	2.36	2.75	3.76	3.08	6.08	5.16
MgO	1.74	2.07	1.93	2.15	8.87	3.98
CaO	4.53	4.76	6.08	4.76	10.36	9.39
Na_2O	3.40	3.29	3.36	3.47	4.17	2.79
K_2O	2.65	3.08	1.84	2.79	.15	.28
H_2O-	.18	.28	.19	.22	.24	.17
H_2O+	.72	1.65	1.47	1.87	2.09	1.21
TiO_2	.38	.58	.32	.44	.98	1.34
P_2O_5	.10	.13	.39	.14	.17	.13
Cr_2O_3					.04	None.
MnO	.10	.07	Trace.	Trace.	Trace.	Trace.
SrO	Trace.	Trace.				
BaO	.07	.06	.10	.11	None.	Trace.
Li_2O	Trace.	Trace.				
SO_3			.10			
FeS_2	.02	.04			1.73	.94
CuS(?)					Trace.	
	100.57	100.36	99.77	100.41	99.35	100.05

G. Wall Rock, Federal Loan mine. A siliceous argillite, of sedimentary origin. Contains quartz, feldspar, biotite, pyrrhotite, and a little calcite. Analysis by Hillebrand, record No. 1478.

H. Altered wall rock, Providence mine. Derived from granodiorite. Analysis by Hillebrand, No. 1478.

I. Altered wall rock, Providence mine, back vein. Derived from granodiorite and schist. Analysis by Hillebrand, No. 1478.

J. Altered wall rock, North Star mine. Derived from uralite diabase. Contains quartz, sericite, calcite, pyrite, and sphene. Analysis by Hillebrand, No. 1478.

K. Altered country rock, Idaho mine. Derived from serpentine. Analysis by Hillebrand, No. 1478.

	G	H	I	J	K
SiO_2	73.63	60.26	59.76	45.74	36.19
Al_2O_3	10.54	15.73	14.45	5.29	4.93
Fe_2O_3	1.87	1.25	1.04	.13	.21
FeO		2.68	3.52	2.06	5.36
MgO	1.84	1.82	2.26	.94	22.94
CaO	2.47	5.44	6.09	23.85	4.60
Na_2O	1.81	1.92	1.12	.11	.16
K_2O	1.89	3.71	3.73	1.29	.06
H_2O-	.11	.33	.26	.22	.18
H_2O+	1.07	2.54	2.58	1.07	2.87
TiO_2	.52	.42	.46	.36	.16
P_2O_5	.13	.12	.16	.07	.05
MnO	Trace?	.04	.09	.26	.12
NiO					.10
SrO	Trace.	Trace.	Trace?	None.	Trace.
BaO	.12	.07	.05	Trace.	Trace.
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.
CO_2	.62	3.99	4.47	18.91	21.82
FeS_2		.08	.24	.49	.22
Fe_7S_8	3.16				
Organic C	.59				
	100.37	100.40	100.28	100.79	99.97

L. Bleached country rock, next to vein, Osborne Hill mine. Derived from sandstone. Analysis by George Steiger, record No. 1541.

M. Altered wall rock, Empire mine. Derived from granodiorite. Analysis by Steiger, No. 1541. Sp. gr., 2.782, 20°.

N. Altered wall rock, Ebaugh Tunnel. Derived from granodiorite. Mainly quartz and sericite, with pyrite, apatite, sphene, and carbonates. Analysis by Steiger, No. 1541. Sp. gr., 2.747, 20°.

O. Altered wall rock, Federal Loan mine. Derived from siliceous argillite. Analysis by Steiger, No. 1541.

	L	M	N	O
SiO_2	71.97	58.43	56.25	34.91
Al_2O_3	15.75	17.40	17.65	15.55
Fe_2O_3	.77	.77	.76	.17
FeO	.45	2.19	2.64	4.96
MgO	.80	1.50	1.69	4.58
CaO	.80	5.25	4.46	11.10
Na_2O	.33	1.76	.30	.19
K_2O	4.88	4.03	6.01	4.28
H_2O-	.30	.30	.30	.30
H_2O+	2.16	2.61	2.36	1.86
TiO_2	.88	None.	.25	1.65
P_2O_5	.15	.13	.21	.82
MnO	None.	None.	None.	None.
BaO	Trace.	None.	.03	None.
SO_3	Trace.	None.	None.	None.
CO_2	.38	4.04	4.82	15.57
FeS_2	.56	1.59	2.87	4.20
	100.18	100.00	100.60	100.14

7. PLACER COUNTY.

First, a series of rocks from the Ophir mining district, described by Lindgren in 14th Ann., p. 249. Analyses by W. F. Hillebrand, record Nos. 1419, 1433, 1434.

A. Granodiorite, quarries at Lincoln, 8 miles west of Ophir. *Tonalose.* Contains feldspars, quartz, biotite, and hornblende. P. R. C. 1526.

B. Pyritiferous amphibolite, Conrad Tunnel. Partly altered. Contains pyrite, hornblende, magnetite, feldspars, quartz, epidote, chlorite, a few scales of mica, rutile, and carbonates. Sp. gr., 2.901, 23°.

C. Dike rock, near camptonite, Caseys Tunnel, Flat Ledge, Duncan Hill. *Placerose.* Contains hornblende, feldspars, pyrite, and apatite, with secondary epidote and quartz.

D. Altered wall rock, Mina Rica vein. Sp. gr., 2.979, 20°.

E. Altered wall rock, Plantz vein. These rocks, D and E, contain quartz, muscovite, a little chlorite, pyrite, and sphene, with carbonates of calcium. magnesium, and iron.

	A	B	C	D	E
SiO_2	65.54	45.56	60.09	37.01	46.13
Al_2O_3	16.52	14.15	16.43	12.99	15.82
Fe_2O_3	1.40	1.20	2.28	.43	.89
FeO	2.49	9.83	3.01	3.57	2.27
MgO	2.52	6.76	4.37	5.49	2.13
CaO	4.88	2.30	5.76	9.78	10.68
Na_2O	4.09	1.57	4.52	.13	.17
K_2O	1.95	1.18	.70	4.02	5.30
H_2O-	.12	.23	.20	.13	.12
H_2O+	.59	4.84	1.16	1.92	2.42
TiO_2	.39	1.11	.63	.85	.67
P_2O_5	.18	.14	.12	.06	.10
MnO	.06	.25	.12	.24	.09
Ni, Zn		Traces.		Traces.	Traces.
SrO	Trace.	Trace.	Trace.	Trace.	Trace.
BaO	Trace.	Trace.	Trace.	Trace.	Trace.
Li_2O	Trace.	Trace.	None.	Trace.	Trace.
SO_3		.03	Trace.	.04	.04
CO_2		3.04	.07	15.04	11.24
FeS_2		7.86	.34	7.99	1.61
Cu_2S (?)		.10			
	100.73	100.15	99.80	99.69	99.68

Second, rocks from other localities in Placer County. Studied also by Lindgren, who furnishes the petrographic data. Analysis A by W. H. Melville, record No. 1346; B, C, D, and E by W. F. Hillebrand, record No. 1419.

A. Granite, Rocklin. *Lassenose.* A normal granite, containing quartz, orthoclase, plagioclase, biotite, muscovite, magnetite, apatite, and zircon, with some secondary chlorite and epidote derived from the biotite. Described by Lindgren in Bull. 150, p. 170. P. R. C. 66.

B. Granodiorite, Donner Pass. *Tonalose.* Contains plagioclase, orthoclase, quartz, hornblende, biotite, and sphene. P. R. C. 1525.

C. Gabbro, 2 miles south of Emigrant Gap, on road to Onion Valley. *Andose.* Contains biotite, hypersthene, diallage, plagioclase, and orthoclase. P. R. C. 1523.

D. Gabbro, same locality as C. *Vaalose.* Contains hypersthene, diallage, plagioclase, and orthoclase. P. R. C. 1524.

E. Quartz diorite, southeast spur of English Mountain. *Placerose.* Contains "basic" plagioclase, augite, and quartz. P. R. C. 1522.

	A	B	C	D	E
SiO_2	73.00	59.48	55.40	55.87	64.67
Al_2O_3	16.38	17.25	15.32	13.52	16.62
Fe_2O_3	None.	2.15	2.70	2.70	.51
FeO	.99	4.06	5.49	5.89	.76
MgO	.48	2.67	5.75	6.51	2.26
CaO	2.42	6.50	9.90	8.87	9.50
Na_2O	4.53	3.53	2.89	2.42	4.10
K_2O	1.87	2.27	1.52	1.72	.34
H_2O-	.52	.09	.03	.09	.08
H_2O+		.71	.38	1.56	.37
TiO_2		.93	.60	.56	.51
P_2O_5		.33	.22	.25	.12
MnO		.11	.11	.10	Trace.
SrO		Trace.	None.	None.	Trace.
BaO		.09	.07	.02	.02
Li_2O		Trace.	Trace.	Trace.	Trace.
	100.19	100.17	100.38	100.08	99.86

8. ELDORADO COUNTY.

A. Granitite, Placerville canal, one-third mile north of Ditch Camp No. 7. *Alaskose.* Collected by W. Lindgren, who reports it as containing biotite, orthoclase, plagioclase, and quartz. Analysis by George Steiger, record No. 1591. P. R. C. 1527.

B. Granodiorite, 2 miles south of Silver Lake Hotel. *Amiatose.* Collected by Lindgren, who reports it as containing hornblende, biotite, plagioclase, and quartz. Analysis by Steiger, No. 1591. Analyses A and B are published by Lindgren in Am. Jour. Sci., 4th ser., vol. 3, p. 306. P. R. C. 1528.

C. Porphyrite, 1 mile southwest of Latrobe. *Dacose.* Published by Turner in 17th Ann., pt. 1, p. 521. Contains abundant plagioclase, less augite, calcite or dolomite, iron bisulphide, a little chlorite, and secondary greenish mica. Analysis by W. F. Hillebrand, record No. 1432. P. R. C. 721.

	A	B	C
SiO_2	77.68	67.45	68.58
Al_2O_3	11.81	15.51	13.04
Fe_2O_3	.72	1.76	.26
FeO	.51	2.21	3.40
MgO	.18	1.10	1.01
CaO	.72	3.60	3.22
Na_2O	2.96	3.47	4.94
K_2O	5.00	3.66	1.90
H_2O-	.04	.14	.16
H_2O+	.27	.03	1.00
TiO_2	.14	.58	.57
P_2O_5	.10	.12	.20
MnO	Trace.		.15
SrO			Trace.
BaO			.10
CO_2			1.31
FeS_2			.15
	100.13	100.23	99.99

9. AMADOR COUNTY.

Rocks collected by H. W. Turner, and analyses published in 14th Ann., p. 441, and 17th Ann., pt. 1, p. 521. Additional data supplied by Turner. Analyses by W. F. Hillebrand, record Nos. 1432, 1456, and 1597.

A. Rhyolite, south point of Buena Vista Peak. *Magdeburgose.* Contains sanidine, quartz, and biotite in a glassy groundmass. P. R. C. 729.

B. Quartz monzonite, North Fork of Mokelumne River. *Amiatose.* Contains plagioclase, microcline, quartz, abundant biotite, iron ore, sphene, apatite, and perhaps rutile. P. R. C. 770.

C. Quartz monzonite, North Fork of the Mokelumne River. *Toscanose.* Like B. P. R. C. 765.

D. Quartz porphyrite schist, 2½ miles southeast of Buena Vista Peak. *Tehamose.* Contains porphyritic quartz and hornblende, also calcite and other carbonates. See 14th Ann. P. R. C. 723.

E. Quartz diorite gneiss, North Fork of Mokelumne River. *Tonalose.* Contains plagioclase, hornblende, quartz, brown mica, accessory biotite, and iron oxide. P. R. C. 764.

F. Diorite porphyry, North Fork of Mokelumne River. *Andose.* Contains plagioclase, brown hornblende, epidote, and a little sulphide of iron and chlorite. P. R. C. 769.

	A	B	C	D	E	F
SiO_2	73.23	70.75	70.43	70.29	57.41	55.18
Al_2O_3	12.73	15.13	15.51	11.83	17.71	17.35
Fe_2O_3	.99	.98	.96	1.30	2.16	2.77
FeO	.16	1.43	1.28	2.08	5.01	3.90
MgO	.22	.73	.37	1.24	3.38	4.80
CaO	.61	3.09	2.76	2.30	6.73	7.98
Na_2O	1.91	3.05	2.75	2.68	3.12	3.42
K_2O	5.17	3.62	5.14	3.05	1.82	1.42
H_2O-	.53	.10	.08	.10	.20	.16
H_2O+	4.51	.51	.40	1.35	1.14	1.52
TiO_2	.09	.42	.24	.29	1.04	.83
P_2O_5	.02	.10	.11	.07	.24	.20
NiO	....	None.	(?)	....	.02	.03
MnO	Trace.	Trace.	Trace.	.12	.15	.15
SrO	None.	.04	.05	Trace?	.04	.06
BaO	.02	.12	.20	.07	.09	.04
Li_2O	Trace.	Trace.	Trace.	None.	Trace.	Trace.
CO_2	....	None.	None.	3.25	None.	None.
FeS_2	....	.06	Trace.	....	None.	.28
	100.19	100.13	100.28	100.02	100.26	100.09

G. Diorite, North Fork of Mokelumne River. *Amadorose.* Contains quartz, feldspar, biotite, sphene, epidote, and secondary chlorite. P. R. C. 771.

H. Diorite, North Fork of Mokelumne River. *Andose.* Contains plagioclase, quartz, hornblende, biotite, apatite, iron ore, epidote, and chlorite. P. R. C. 772.

I. Plagioclase gneiss, North Fork of Mokelumne River. *Hessose-andose.* Contains plagioclase, hornblende, biotite, and apatite. P. R. C. 768.

J. Plagioclase gneiss, North Fork of Mokelumne River. *Bandose.* Contains plagioclase, hornblende, brown mica, apatite, epidote, and grains of iron ore. P. R. C. 767.

	G	H	I	J
SiO_2	69.66	55.86	52.21	46.63
Al_2O_3	17.57	19.30	18.79	19.47
Fe_2O_3	.21	.91	2.71	3.26
FeO	1.04	4.78	5.30	6.63
MgO	.58	2.94	5.11	5.37
CaO	4.54	7.31	8.01	9.15
Na_2O	4.91	3.52	3.31	3.19
K_2O	.71	1.52	1.60	1.55
H_2O-	.05	.19	.12	.10
H_2O+	.50	1.23	1.35	1.61
TiO_2	.21	1.20	1.16	1.82
P_2O_5	.03	.38	.36	.66
V_2O_3	....	....	....	.02
NiO	None.	Trace.	Trace.	.02
MnO	Trace.	.16	.06	.21
SrO	.05	.04	....	.06
BaO	.03	.13	.08	.14
Li_2O	None.	Trace.	Trace.	Trace.
CO_2	None.	None.	None.	None.
FeS_2	Trace?	.39	.06	.19
	100.09	99.86	100.23	100.08

K. Wollastonite gneiss, North Fork of Mokelumne River. Mainly wollastonite, but garnet, quartz, and sphene are also present. P. R. C. 766.

L. Melaphyre tuff, altered basalt, west of Jackson. Contains augite and plagioclase, with secondary quartz, chlorite, and chrysotile. Originally glassy in part, but devitrified. See 14th Ann. P. R. C. 722.

M. Reddish-brown mica separated from pyroxenic gneiss, North Fork of Mokelumne River, about 1 kilometer above mouth of Bear River. Described by Turner in Am. Jour. Sci., 4th ser., vol. 7, p. 294. Analysis by William Valentine, record No. 1736.

	K	L	M
SiO_2	50.67	49.24	36.62
Al_2O_3	6.37	14.79	14.37
Fe_2O_3	.31	1.36	4.04
FeO	.50	8.00	17.09
MgO	.58	6.89	9.68
CaO	40.34	10.74	1.48
Na_2O	.14	2.76	.45
K_2O	.22	.88	8.20
H_2O-	.08	.20	.90
H_2O+	.31	2.97	3.26
TiO_2	.20	.96	3.03
P_2O_5	None.	.17	None.
NiO	None.	....	....
MnO	Trace.	.18	.40
SrO	None.	Trace.	Trace.
BaO	None.	.04	.33
Li_2O	None.	Trace.	Trace.
F	....	....	.10
CO_2	.52	.90	....
	100.24	100.08	99.95
Less O	....	....	.04
	....	....	99.91

10. CALAVERAS COUNTY.

Rocks collected by H. W. Turner, and described in 14th Ann., p. 441. Additional data supplied by Turner relative to analysis B. Analyses by W. F. Hillebrand, record No. 1432.

A. **Metadacite**, 1¾ miles southeast of Milton. *Vulcanose.* Contains quartz, feldspar, and hornblende. P. R. C. 777.

B. **Metadacite**, 1½ miles northeast of Milton. *Lassenose.* Contains feldspar, quartz, epidote, chlorite, and iron ore, in a groundmass made up probably of feldspar and quartz. P. R. C. 752.

C. **Meta-andesite**, 1½ miles northward from Jenny Lind. *Placerose.* Contains quartz, plagioclase, epidote, and chlorite derived from augite.

	A	B	C
SiO_2	72.24	71.19	61.37
Al_2O_3	13.84	13.81	15.41
Fe_2O_3	1.45	1.45	3.15
FeO	1.86	1.68	3.89
MgO	1.10	.74	3.48
CaO	3.40	2.87	4.42
Na_2O	4.43	4.24	3.76
K_2O	.39	1.82	.34
H_2O-	.17	.15	.29
H_2O+	.69	.92	2.70
TiO_2	.41	.35	.60
P_2O_5	.10	.08	.08
MnO	.12	.07	.47
SrO	Trace.	Trace.	Trace.
BaO	.08	.16	.08
CO_2	....	.82	....
	100.28	100.35	100.04

11. TUOLUMNE COUNTY.

Rocks collected by H. W. Turner, and partly described in his papers in 14th and 17th Ann. The latites were named and described by Ransome in Bull. 89. Some additional data have been furnished by Turner.

A. **Soda syenite porphyry**, dike east of Moccasin Creek. *Tuolumnose.* Consists mainly of albite, with a greenish mineral which is probably ægirite. Analysis by H. N. Stokes, record No. 1563. P. R. C. 773.

B. Augite syenite, dike on Turnback Creek, about 1 mile north of Carter post office. *Highwoodose.* Contains orthoclase and augite, with less plagioclase and quartz. Analysis by Stokes, No. 1642. P. R. C. 789.

C. Diorite, dike 1½ miles southeasterly from Sonora. *Tonalose.* Contains feldspar largely altered to hornblende. A few black grains are probably iron ore. Analysis by W. F. Hillebrand, record No. 1548. P. R. C. 759.

D. Quartz-pyroxene diorite, large area east of Sonora. *Harzose.* Contains plagioclase, quartz, biotite, augite, rhombic pyroxene, and a trace of iron ore. Analysis by Hillebrand, No. 1548. P. R. C. 760.

E. Diorite, dike about 1½ miles southeasterly from Sonora. *Camptonose.* Contains altered plagioclase and hornblende, with epidote, chlorite, and iron bisulphide as secondary products. Analysis by Hillebrand, No. 1548. P. R. C. 761.

	A	B	C	D	E
SiO_2	67.53	61.28	58.05	57.80	53.46
Al_2O_3	18.57	14.71	15.46	16.43	14.81
Fe_2O_3	1.13	1.21	1.69	1.62	2.60
FeO	.08	2.85	5.09	6.51	5.15
MgO	.24	1.69	4.84	4.14	7.27
CaO	.55	5.61	6.94	7.21	8.44
Na_2O	11.50	2.99	2.86	2.35	2.64
K_2O	.10	7.70	2.14	2.29	1.30
H_2O-	.15	.28	.10	.11	.12
H_2O+	.31	.43	2.02	.38	2.13
TiO_2	.07	.41	.72	.70	.70
P_2O_5	.11	.16	.16	.19	.16
MnO	Trace.	Trace.	.14	.18	.18
NiO	....	....	None.	.03	.05
SrO	Trace.	.04	Trace.	Trace?	Trace.
BaO	....	.72	.07	.09	.05
Li_2O	....	....	Trace.	Trace.	Trace.
SO_3	Trace.	.08	....	....	....
CO_2	....	....	None.	None.	.44
F	Trace.	....	....	....	....
FeS_2	....	....	None.	None.	.26
	100.34	100.16	100.28	100.03	99.76

F. Biotite-augite latite, 4 miles southwest of Clover Meadow. *Toscanose.* Called "trachyte-andesite tuff" in first edition of this bulletin. Contains plagioclase, biotite, augite, magnetite, apatite, and glass. Analysis by W. F. Hillebrand, record No. 1597. P. R. C. 762.

G. Augite latite, Dardanelle flow, near Clover Meadow. *Monzonose.* Contains plagioclase, in part labradorite, augite, iron ore, some olivine, apatite, and brown glass. The potassium is probably in the glass, as no potash mineral was observed. Analysis by H. N. Stokes, record No. 1645. P. R. C. 785.

H. Augite latite, Table Mountain. *Shoshonose.* Called "basalt" in first edition. Contains labradorite, olivine, augite, and magnetite. Analysis by Hillebrand, record No. 1273. P. R. C. 724.

I. Augite latite, Table Mountain, near Clover Meadow. *Shoshonose.* Contains labradorite, augite, olivine, magnetite, apatite, and glass. Analysis by George Steiger, record No. 1697. P. R. C. 763.

	F	G	H	I
SiO_2	62.33	59.43	56.19	56.78
Al_2O_3	17.30	16.68	16.76	16.86
Fe_2O_3	3.00	2.54	3.05	3.56
FeO	1.63	3.48	4.18	2.93
MgO	1.05	1.84	3.79	3.41
CaO	3.23	4.09	6.53	6.57
Na_2O	4.21	3.72	2.53	3.19
K_2O	4.46	5.04	4.46	3.48
H_2O-	.44	.27	.34	.15
H_2O+	.75	.72	.66	1.21
TiO_2	1.05	1.38	.69	1.15
P_2O_5	.29	.58	.55	.42
ZrO_2	.04	.08		
V_2O_3	.01			
MnO	.08	Trace.	.10	None.
SrO	.05	Trace.	Trace.	
BaO	.24	.14	.19	Trace.
Li_2O	Trace.	None.	Trace.	
CO_2				.18
Cl		.05		
F		Trace.		
C	.11			
FeS_2	.06			
	100.33	100.04	100.02	99.89

J. Amphibole gabbro, Beaver Creek, Big Trees quadrangle. *Hessose*. Contains labradorite and amphibole, with a little pyrite and pyrrhotite. Analysis by H. N. Stokes, record No. 1752.

K. Amphibole separated from J. Analysis by William Valentine, record No. 1733.

L. Olivine gabbro, just east of south end of Phoenix reservoir. *Corsose*. Contains plagioclase, a few grains of alkali feldspar, augite, rhombic pyroxene, amphibole, olivine, magnetite, and iron sulphide, with a little secondary chlorite and epidote. Analysis by H. N. Stokes, record No. 1750.

For description of J and K see Turner, Am. Jour. Sci., 4th ser., vol. 7, p. 294.

	J	K	L
SiO_2	47.27	46.08	43.41
Al_2O_3	20.82	10.52	23.15
Fe_2O_3	1.85	2.81	3.72
FeO	4.26	8.30	4.39
MgO	6.44	14.40	7.65
CaO	13.02	12.64	14.27
Na_2O	2.75	1.62	.82
K_2O	.22	.34	.22
H_2O-	.08	.17	.18
H_2O+	1.27	1.97	1.53
TiO_2	.92	.77	.39
P_2O_5	.74	.18	.02
V_2O_3	.02	.04	
Cr_2O_3	Trace.		None.
MnO	Trace.	.15	.08
SrO	Trace.		
Li_2O	None.	None.	Trace.
CO_2			.10
FeS_2	.20		.14
Cl	Trace.		Trace.
	99.86	99.99	100.07

12. MARIPOSA COUNTY.

Rocks collected by H. W. Turner, and partly described in his papers in 14th and 17th Ann. Additional data supplied by Turner.

A. Soda granulite or aplite, about 4 miles west of Mariposa. *Mariposose.* See 17th Ann., pt. 1, p. 721. Contains plagioclase (albite?) and micropegmatite, with less epidote, quartz, sphene, and apatite. Analyses by W. F. Hillebrand, record No. 1461. P. R. C. 748.

B. Micropegmatite, Agua Fria Creek. *Lassenose.* See 17th Ann., pt. 1, p. 691. Contains quartz, plagioclase, brown mica, epidote, and a little iron ore. Analysis by Hillebrand, No. 1461. P. R. C. 746.

C. Soda granite porphyry, Merced River, below the mouth of the North Fork. *Lassenose.* Published in 17th Ann. Contains feldspar, largely albite, hornblende, muscovite, abundant epidote, apatite, and a little iron ore. Analysis by George Steiger, record No. 1573. P. R. C. 774.

D. Granite prophyry, about one-fourth of a mile north of Lake Tenaya, Yosemite National Park. *Toscanose.* See 14th and 17th Ann. Contains orthoclase, quartz, plagioclase, and biotite, with a little iron ore and sphene. Analysis by Hillebrand, record No. 1432. P. R. C. 726.

E. Granite, west of Lake Tenaya, Yosemite National Park. *Lassenose.* See 14th and 17th Ann. Contains quartz, orthoclase, plagioclase, and biotite, with some hornblende, iron ore, sphene, and apatite. Analysis by Hillebrand, No. 1432. P. R. C. 725.

	A	B	C	D	E
SiO_2	74.21	73.18	71.88	72.48	66.28
Al_2O_3	14.27	13.66	15.57	14.06	16.03
Fe_2O_3	.35	.21	1.07	.89	1.80
FeO	.50	2.24	.30	1.05	1.88
MgO	.28	.93	.68	.62	1.12
CaO	1.71	2.10	2.03	2.17	3.75
Na_2O	7.62	3.70	5.81	3.30	4.10
K_2O	.10	2.72	1.80	4.75	3.49
H_2O-	.15	.10	.11	.16	.10
H_2O+	.23	.57	.68	.35	.39
TiO_2	.30	.25	.17	.28	.54
P_2O_5	.07	.09	.08	.09	.30
MnO	None.	.07	None.	Trace.	.05
SrO	Trace.	Trace.	.08	Trace.	Trace.
BaO	None.	.10	.02	.08	.08
Li_2O	Trace.	Trace.	None.	Trace.	Trace.
CO_2	....	.17	None.	....	....
	99.99	100.09	100.28	100.28	99.91

F. Amphibole-biotite granite, Nevada Falls trail, Yosemite Valley. *Toscanose.* Contains alkali feldspar, plagioclase, quartz, amphibole, biotite, magnetite, and apatite.

G. Biotite granite, base of El Capitan, Yosemite Valley. *Toscanose.* Contains alkali feldspar, plagioclase, quartz, biotite, titanite, apatite, and iron oxides.

H. Brown mica separated from G.

Analyses F, G, and H by William Valentine, record Nos. 1732, 1733. Samples G and H are described by Turner in Am. Jour. Sci., 4th ser., vol. 7, p. 294.

	F	G	H
SiO_2	66.83	71.08	35.64
Al_2O_3	15.24	15.90	18.62
Fe_2O_3	2.73	.62	5.54
FeO	1.66	1.31	14.60
MgO	1.63	.54	9.72
CaO	3.59	2.60	.90
Na_2O	3.10	3.54	.38
K_2O	4.46	4.08	9.22
H_2O-	None.	None.	.48
H_2O+	.56	.30	2.54
TiO_2	.54	.22	1.12
P_2O_5	.18	.10	.20
ZrO_2	.04	.08	....
MnO	.10	.15	.79
SrO	.03	.02	....
BaO	.11	.04	Trace.
Li_2O	Trace.	Trace.	Trace.
CO_2	Trace.	Trace.	....
Cl	.02	.02	....
F	....	....	.26
	100.82	100.00	100.01
Less O	....	....	.11
	....	....	99.90

I. Amphibole picrite, near Sequoia post office, Yosemite National Park. *Uvaldose.* Collected by Turner but not described. Analysis by George Steiger, record No. 1884.

J. Amphibole-pyroxene rock, perknite, 3 miles northeast of Coulterville. *SR. 2 of sec. 2 of minnesotase.* Described by Turner in Jour. Geology, vol. 9, p. 508. Analysis by George Steiger, record No. 1860. Contains pyroxene and amphibole, with a little quartz and pyrrhotite.

K. Amphibole separated from quartz monzonite, Tioga road, southeast of Mount Hoffman. Sp. gr., 3.203, 21.5°.

L. Mica separated from the same rock as I. Sp. gr., 3.05, 21°.

Analyses K and L by W. F. Hillebrand, record No. 1774. Samples K and L are described by Turner in Am. Jour. Sci., 4th ser., vol. 7, p. 294.

	I	J	K	L
SiO_2	43.17	48.04	47.49	35.75
Al_2O_3	11.42	7.82	7.07	14.70
Fe_2O_3	4.97	2.01	4.88	4.65
FeO	6.36	9.32	10.69	14.08
MgO	16.97	13.33	13.06	12.37
CaO	11.62	13.01	11.92	.17
Na_2O	1.11	.69	.75	.32
K_2O	.10	.48	.49	9.19
H_2O-	.22	.17	....	1.03
H_2O+	2.51	2.90	1.86	3.64
TiO_2	1.23	1.16	1.21	3.16
P_2O_5	.04	Trace.	None.	.03
S	.06	.90	....	....
SO_3	....	.23	....	....
V_2O_3	....	....	.04	.06
Cr_2O_3	....	....	None.	Trace.
MnO	.14	None.	.51	.45
NiO, CoO	....	....	.02	.02
BaO	....	None.	None.	.12
SrO	....	....	None.	(?)
Li_2O	....	....	Trace.	....
CO_2	.71	None.	....	....
F	....	....	.06	.17
	100.63	100.06	100.05	99.90
Less O	.03	.45	.02	.07
	100.60	99.61	100.03	99.83

M. Quartz-mica diorite, Chowchilla River. *Tonalose.* See 17th Ann., pt. I, p. 691. Contains plagioclase, quartz, a little orthoclase (?), brown mica, hornblende, rather abundant apatite, a little iron ore; one zircon-like crystal was noted. Analysis by W. F. Hillebrand, record No. 1461. P. R. C. 745.

N. Quartz-mica diorite, Yaqui Creek. *Tonalose.* For the Educational Series of Rocks. Contains plagioclase, quartz, biotite, hornblende, a little pyroxene, iron ore, and apatite. Analysis by George Steiger, record No. 1643. Described by Turner in Bull. 150, p. 339.

O. Diabase, dike 1½ miles northeast of Hornitos. *Auvergnose.* See 17th Ann., pt. 1, p. 694. Contains plagioclase, partly labradorite, augite, brown hornblende, and iron ore. Analysis by Hillebrand, No. 1461. P. R. C. 750.

P. Igneous rock, near Cathay Hill. *Rossweinose.* See 17th Ann., pt. 1, p. 694. Contains two minerals unidentified; neither is olivine. Analysis by Hillebrand, No. 1461. P. R. C. 749.

	M	N	O	P
SiO_2	62.62	58.09	51.32	47.75
Al_2O_3	17.51	17.46	15.28	10.56
Fe_2O_3	.49	1.12	.47	.74
FeO	4.06	5.08	8.59	8.34
MgO	2.84	4.06	7.25	19.09
CaO	5.49	6.24	11.58	9.62
Na_2O	3.49	2.94	2.92	1.32
K_2O	1.76	2.02	.22	.12
H_2O-	.22	.29	.06	.05
H_2O+	.92	1.45	.95	2.06
TiO_2	.55	.95	1.23	.37
P_2O_5	.12	.17	.25	.03
Cr_2O_3	....	....	....	.24
NiO	....	....	....	.07
MnO	.05	None.	.16	.10
SrO	Trace.	.04	Trace.	Trace.
BaO	Trace.	.07	None.	None.
Li_2O	Trace.	None.	Trace.	Trace.
CO_2	....	.21	....	....
SO_3	....	.05	....	....
Cl	....	.02	....	....
F	....	Trace.	....	....
C	....	.11	....	....
	100.12	100.37	100.28	100.46

Q. Feldspathic mica schist, Chowchilla River. See 17th Ann., pt. 1, p. 691. Contains quartz, feldspar, biotite, muscovite, apatite, and specular iron. Analysis by W. F. Hillebrand, record No. 1461. P. R. C. 744.

R. Andalusite hornfels, Yaqui Gulch. Principally quartz, andalusite, brown and white mica, black graphite-like grains, a little iron ore, and probably feldspar. Analysis by George Steiger, record No. 1643. Described by Turner in Bull. 150, p. 342.

S. Andalusite schist, Chowchilla River. See 17th Ann., pt. 1, p. 691. Contains quartz, biotite, andalusite, sericite, a little muscovite, probably graphite, iron ore, a few garnets, and apparently chlorite. Analysis by Hillebrand, No. 1461. P. R. C. 743.

T. Chiastolite schist, Yaqui Gulch. Contains chiastolite, sillimanite, brown mica, sericite (?) probably graphite, and clear grains which appear to be quartz and feldspar. Analysis by Steiger, No. 1643. Described by Turner in Bull. 150, p. 342. P. R. C. 135.

U. Hornfels, Agua Fria Creek. See 17th Ann., pt. 1, p. 691. Contains quartz, brown mica, iron ore, and plagioclase. Analysis by Hillebrand, No. 1461. P. R. C. 747.

	Q	R	S	T	U
SiO_2	70.40	65.10	64.28	62.15	68.27
Al_2O_3	14.70	17.77	17.28	19.34	14.03
Fe_2O_3	.65	1.95	1.10	4.23	.46
FeO	2.57	3.29	5.34	2.25	4.68
MgO	1.47	1.43	2.57	1.88	2.23
CaO	1.63	1.38	1.19	1.50	3.89
Na_2O	3.17	2.25	.91	1.60	2.29
K_2O	3.46	2.45	2.93	3.07	3.35
H_2O-	.19	.47	.20	.19	.08
H_2O+	.91	2.49	2.72	1.79	.98
TiO_2	.51	.72	.65	.80	.57
P_2O_5	.05	.14	.27	.15	.21
MnO	.08	None.	.09	Trace.	.04
SrO	Trace.	None.	Trace.	None.	Trace.
BaO	.09	None.	.10	.04	.08
Li_2O	Trace.	None.	Trace.	None.	Trace.
SO_3	....	.03	....	.13	....
Cl	....	Trace.	....	None.	....
F	....	.12	....	.22	....
C	.15	1.21	.43	1.12	....
	100.03	100.80	100.06	100.46	100.16
Less O	....	.06	....	.10	....
	....	100.74	....	100.36	....

13. THE QUICKSILVER REGION.

Rocks described by Becker in Mon. XIII. Analyses made by W. H. Melville in the San Francisco laboratory. With one exception (the serpentine from New Idria) all the rocks are from the districts north of San Francisco.

A. Pseudodiabase, near Mount St. Helena. *Ornose*. Contains augite, hornblende, oligoclase, albite, zoisite, ilmenite, leucoxene, and a little chlorite. P. R. C. 1459.

B. Pseudodiabase, Sulphur Bank. *Ornose*. Contains oligoclase, a little quartz, pyroxene, hornblende, ilmenite, sphene, serpentine, and chlorite. P. R. C. 1460.

C. Pseudodiorite, Knoxville. *Rossweinose*. Mainly actinolite, with a little white mica, chlorite, serpentine, sphene, rutile, and zircon. P. R. C. 1461.

D. Glaucophane schist, Sulphur Bank. Mainly glaucophane and zoisite. Quartz, albite, muscovite, and sphene are also present. P. R. C. 1462.

	A	B	C	D
SiO_2	49.08	51.28	50.44	49.68
Al_2O_3	14.68	15.05	8.18	13.60
Fe_2O_3	1.95	2.42	1.06	1.86
FeO	9.63	8.01	6.29	8.61
MgO	6.69	6.07	17.63	6.26
CaO	10.09	7.08	11.55	10.97
Na_2O	4.60	4.43	2.98	3.09
K_2O	.20	.12	.50	.12
H_2O-	.27	.39	.07	....
H_2O+	1.18	2.96	.92	3.84
TiO_2	1.72	1.33	....	1.31
P_2O_5	.23	.13	....	.21
Cr_2O_3	....	....	.48	....
MnO	.15	.25	.21	.04
NiO	....	.10	....	....
	100.47	99.62	100.31	99.59

E. Andesitic obsidian, Clear Lake. *Liparose*. Shows grains of plagioclase, augite, and hypersthene. Sp. gr., 2.391. P. R. C. 1463.

F. Andesite (asperite), Clear Lake. *Yellowstonose*. Contains pyroxene, plagioclase, magnetite, and sometimes biotite. Pyroxene mostly rhombic. Sp. gr., 2.664. P. R. C. 1464.

G. Obsidian, south of Borax Lake. *Varingose*. Sp. gr., 2.390. P. R. C. 1465.

H. Basalt, south of Burns Valley. *Andose*. Rich in olivine, with a microlitic groundmass of plagioclase and augite. Sp. gr., 2.380. P. R. C. 1466.

I. Ordinary basalt, Knoxville. P. R. C. 1467.

	E	F	G	H	I
SiO_2	74.01	65.43	75.40	57.37	51.66
Al_2O_3	12.95	17.10	7.72	15.66	11.22
Fe_2O_3	....	2.39	1.41	2.06	7.62
FeO	1.42	1.19	....	4.46	
MgO	.48	1.48	1.26	8.84	13.61
CaO	.99	3.88	1.55	4.94	7.72
Na_2O	5.34	3.66	8.09	3.05	5.98
K_2O	4.65	2.83	4.52	1.51	.89
H_2O-	....	.20	.43	.61	1.06
H_2O+	.29	.36		.12	
TiO_2	.24	.83	....	.60	Trace.
P_2O_5	.01	Trace.	....	.02	....
Cr_2O_3	....	....	....	....	.25
MnO	Trace.	.70	.12	.27	.12
NiO	....	.20	....	.41	....
Cl	.07	....	.12	....	....
	100.45	100.25	100.62	99.92	100.13

J. Light-green marmolitic serpentine, New Idria. P. R. C. 1468.

K. Black serpentine, Sulphur Bank. P. R. C. 1469.

L. Light-green serpentine, Sulphur Bank. P. R. C. 1470.

	J	K	L
SiO_2	41.54	39.64	41.86
Al_2O_3	2.48	1.30	.69
FeO	1.37	7.76	4.15
MgO	40.42	37.13	38.63
H_2O	14.18	13.81	14.16
Cr_2O_3	....	.29	.24
MnO	....	.12	.20
NiO	.04	.33	Trace.
	100.03	100.38	99.93

14. MOUNT DIABLO.

Described by Turner and Melville in Bull. Geol. Soc. America, vol. 2, pp. 383–414. Analyses by W. H. Melville. Those with record numbers were made in the Washington laboratory; the others were made in the laboratory at San Francisco.

A. Diabase, Mitchell Canyon. *Auvergnose.* Composed of augite, plagioclase, and ilmenite, with uralite and chlorite secondary.

B. The same rock, partly altered and partly uralitic. *Ornose.* Called "diabase-diorite" by Turner.

C. Pyroxenite, near Bagley Creek. *Cecilose.* Composed of bronzite and diallage. Equivalent to the websterite of North Carolina. P. R. C. 735.

D. Glaucophane schist, Pine Canyon. Contains numerous cinnamon garnets.

A, B, and C have the record No. 1247.

	A	B	C	D
SiO_2	52.06	51.58	53.25	47.84
Al_2O_3	14.34	14.99	2.80	16.88
Fe_2O_3	2.11	2.04	.69	4.99
FeO	7.74	8.36	5.93	5.56
MgO	9.26	6.51	19.91	7.89
CaO	8.05	.59	16.22	11.15
Na_2O	1.74	.08	.19	3.20
K_2O	.73	.31	Trace.	.46
H_2O-	.59	.34	.05	.17
H_2O+	2.90	2.67	.24	1.81
TiO_2	.47	1.05	....	....
P_2O_5	.13	.24	....	.14
Cr_2O_3	....	....	.54	....
NiO	....	....	.07	....
MnO	Trace.	Trace.	.09	.56
	100.12	99.76	99.98	100.65

E. Crystalline gabbro, Bagley Creek. *Kedabekose*. Contains plagioclase and diallage. Record No. 1166.

F. Shaly gabbro. Friable, containing carbonates and sulphates. Somewhat resembles serpentine.

G. Shaly gabbro, like F, much resembling a true serpentine.

According to Turner, F and G are merely weathered layers of the gabbro.

	E	F	G
SiO_2	47.49	45.43	45.69
Al_2O_3	15.81	12.55	13.30
Fe_2O_3	1.07	....	1.85
FeO	4.50	6.50	4.72
MgO	10.39	13.41	13.06
CaO	15.53	12.39	13.50
Na_2O	1.16	1.71	1.36
K_2O	Trace.	.11	Trace.
H_2O-	1.20	2.41	2.29
H_2O+	1.83	2.74	2.47
P_2O_5	Trace.	.04	.06
NiO	.06	....	....
MnO	.41	.21	.24
CO_2	....	2.35	1.89
SO_3	....	.24	.43
Organic matter	....	Trace.	....
	99.45	100.09	100.86

The following analyses are of serpentines derived from a peridotite-pyroxenite dike:

H. Almost black. Possibly derived from adjacent shale.

I. Almost black. Derived from pyroxenite.

J. Bastite. Derived from pyroxenite. Record No. 1166.

K. Friable serpentine.

	H	I	J	K
SiO_2	38.53	40.50	36.57	36.96
Al_2O_3	14.55	.78	.95	.39
Fe_2O_3	2.65	4.01	7.29	5.00
FeO	4.01	2.04	.37	2.34
MgO	21.79	37.43	40.27	33.84
CaO	3.13	.39	.14	3.81
Na_2O	.07	.28	.31	.34
K_2O	.88	.16	Trace.	.14
H_2O-	4.51	2.81	.94	2.16
H_2O+	9.56	10.94	12.43	14.02
P_2O_5	Trace.	Trace.	....	.02
Cr_2O_3	Trace.	.41	.33	.78
NiO	Trace.	.11	.31	Trace.
MnO	.32	.13	.10	.09
	100.00	99.99	100.01	99.89

Accidental organic matter was deducted from analyses H and I, with subsequent recalculation of the data to 100 per cent.

L. Serpentine.

M. Talclike yellowish-green serpentine.

N. Weathered serpentine.

O. Olive colored, probably serpentine.

Samples H, I, and J are from near Bagley Creek; K, L, M, and N from near Arroyo del Cerro; O from Ferguson ravine. M and O carry considerable chromite.

	L	M	N	O
SiO_2	34.84	32.27	41.52	30.98
Al_2O_3	.42	11.45	1.57	1.04
Fe_2O_3	6.08	Trace.	3.50	4.88
FeO	1.85	5.05	1.07	2.01
MgO	30.74	33.30	36.84	38.44
CaO	7.02	.41	.44	.22
Na_2O	.42	Trace.		.40
K_2O	.07	Trace.		.16
H_2O-	1.67	.44	3.32	.39
H_2O+	15.72	12.40	12.51	20.43
P_2O_5	.04	Trace.		Trace.
Cr_2O_3	.68	5.19		.34
NiO	Trace.	.19		
MnO	.01	Trace.	.29	.42
SO_3				.44
	99.56	100.70	101.06	100.15

15. SAN DIEGO COUNTY.

Rocks collected and analyzed by W. T. Schaller. Record Nos. 2120, 2309, 2646, 2810.

A. Fine grained pegmatite, Catharina mine, Pala.

B. Graphic granite, same locality as A. *Liparose.*

C. Pegmatite, Rincon. *Liparose.*

D. Quartz-augite rock, Hiriart Hill, Pala, San Diego County. *III. 4. 5. 5.* Mainly quartz and augite. P. R. C. 1871.

E. Matrix of dumortierite, near Dehesa, San Diego County. Consists chiefly of quartz, with andalusite or sillimanite. For details see Bull. 262, p. 96.

	A	B	C	D	E
SiO_2	74.29	72.80	74.74	57.29	75.54
Al_2O_3	14.93	15.07	15.38	12.07	18.65
Fe_2O_3	.77	.26	.77	.89	.35
FeO	.79	.21		5.70	.06
MgO	None.	None.	.03	4.02	None.
CaO	.41	None.	.26	17.77	.03
Na_2O	4.67	3.35	4.20	.39	
K_2O	2.38	7.92	4.26	Trace.	
H_2O-	.56	.30	.58	.37	1.10
H_2O+				.31	3.67
TiO_2				.70	.48
ZrO_2					.06
P_2O_5				.04	Trace.
FeS_2					.10
MnO	.89	Trace.	.04	.58	
	99.69	99.91	100.26	100.13	100.04

16. MISCELLANEOUS ROCKS.

A. Rhyolitic obsidian, Medicine Lake, Modoc County. *Toscanose.* Collected by J. S. Diller, who reports it to be a banded obsidian, containing a few minute feldspar crystals. The banding is due to a multitude of trichites. Analysis by L. G. Eakins, record No. 1072.

B. Rhyolite, Hyampom, South Fork of Trinity River, Trinity County. *Tehamose.* Almost wholly made up of particles of clear glass. Collected and described by Diller. Analysis by George Steiger, record No. 1427. P. R. C. 1455.

C. Tuff from Redding Creek Basin, Trinity County. Collected by J. S. Diller. Analysis by E. T. Allen, record No. 2020.

D. Tuff from Hayfork Valley, Big Bar quadrangle, Trinity County. Collected by Diller. Analysis by R. C. Wells, record No. 2509. The three tuffs are described by Diller in Bull. 470.

E. Diabase porphyrite, one-half mile west of Browns Valley, Yuba County. *Auvergnose.* Collected and described by W. Lindgren, Contains augite, plagioclase, magnetite, chlorite, and epidote. Analysis by W. F. Hillebrand, record No. 1419.

F. Amphibolitic schist, 1 mile northeast of Browns Valley, Yuba County. Collected and described by W. Lindgren. From metamorphosis of C. Contains chiefly green hornblende and feldspar. Analysis by Hillebrand, No. 1419.

	A	B	C	D	E	F
SiO_2	73.51	70.40	60.23	63.55	48.26	54.13
Al_2O_3	14.42	13.50	18.64	17.10	14.83	14.53
Fe_2O_3	.46	1.31	3.81	3.21	3.27	1.50
FeO	1.49	1.61	.88	.92	5.97	5.25
MgO	.33	.37	1.64	.43	8.77	10.93
CaO	1.26	.56	6.04	.82	11.38	4.91
Na_2O	4.03	2.11	3.87	2.12	1.57	3.53
K_2O	4.29	2.39	1.46	2.30	1.13	.32
H_2O-	.04	1.05	.95	4.20	.10	.20
H_2O+		7.41	1.97	5.13	3.37	4.01
TiO_2			.57	.41	.51	.46
ZrO_2			.01			
CO_2			None.	None.	1.24	
P_2O_5	.40	.08	.20	.10	.25	.09
S				Trace.		
Cr_2O_3			Trace.			
MnO	Trace.	Trace.	Trace.	.03	.15	.15
BaO			.11		.05	.02
SrO			.05		Trace.	Trace.
Li_2O					Trace.	None.
	100.23	100.79	100.43	100.32	100.85	100.03

G. Basalt, base of a lava flow, east of the head of San Joaquin River, Madera County. *Andose.* Description supplied by Turner. Contains pyroxene, partly augite, plagioclase, olivine, and iron ores. Analysis by W. F. Hillebrand, record No. 1767.

H. Olivine basalt, west peak of the Dardanelles, Alpine County. *Hessose.* Described by Ransome in Bull. 89. Contains olivine, largely altered to iddingsite, plagioclase, serpentine, and augite. Analysis by George Steiger, record No. 1697.

I. Mica separated from quartz monzonite, near Bloods station, Alpine County. Described by Turner in Am. Jour. Sci., 4th ser., vol. 7, p. 294. Analysis by William Valentine, record No. 1736.

	G	H	I
SiO_2	51.89	48.76	35.62
Al_2O_3	15.28	16.60	15.24
Fe_2O_3	3.10	5.60	4.69
FeO	3.60	5.01	13.67
MgO	8.68	6.93	12.70
CaO	7.38	8.79	.95
Na_2O	3.27	2.47	.50
K_2O	2.57	.66	7.72
H_2O-	1.17	1.49	.94
H_2O+	1.37	2.19	4.36
TiO_2	.91	1.26	2.61
P_2O_5	.61	.19	
ZrO_2	Trace.		
MnO	.12	None.	
NiO	.02		
SrO	.09		Trace.
BaO	.15	Trace.	.26
Li_2O	Trace.		Trace.
CO_2	None.	.42	
	100.21	100.37	100.00

J. Typical diabase, 1 mile north of Bella Vista ranch houses, San Mateo County. *Andose.* Contains plagioclase, augite, olivine, apatite, ilmenite, and magnetite, with secondary serpentine, chlorite, iron ores, calcite, analcite, and natrolite. P. R. C. 1473.

K. Diabase, basaltic facies, Mendigo Hill, San Mateo County. *Andose.* Contains plagioclase, augite, olivine, ilmenite, and magnetite, with secondary calcite, serpentine, chlorite, iddingsite, iron oxides, analcite, and natrolite. P. R. C. 1603.

Rocks J and K are described by Haehl and Arnold in Proc. Am. Philos. Soc., vol. 43, p. 16. Analyses by E. T. Allen, record No. 1958.

L. Bronzite-olivine aleutite, south end of Panamint Range. *Andose.* Contains plagioclase, bronzite, and olivine in a glassy to microcrystalline groundmass carrying much magnetite. P. R. C. 1905.

M. Hornblende-quartz diorite, Fremont Peak, Mohave Desert. Contains hornblende, plagioclase, subordinate quartz, and apatite, with secondary muscovite and epidote.

N. Alaskite, Fremont Peak. *Toscanose-tehamose.* Essential minerals, quartz and orthoclase.

Rocks L, M, and N collected and described by J. E. Spurr. Analyses by W. F. Hillebrand, record No. 1881.

	J	K	L	M	N
SiO_2	50.12	49.60	53.98	52.55	76.26
Al_2O_3	18.52	16.56	17.86	17.61	13.43
Fe_2O_3	2.47	4.28	4.61	4.24	.11
FeO	4.11	4.44	2.27	4.98	.06
MgO	2.68	5.38	3.30	4.17	.04
CaO	8.99	9.22	7.55	8.02	1.06
Na_2O	5.22	3.31	4.19	3.41	2.95
K_2O	1.46	1.25	2.59	1.49	5.44
H_2O-	1.64	1.44	.56	.25	.19
H_2O+	3.09	2.58	.50	2.13	.51
TiO_2	1.33	1.86	1.10	.86	.07
ZrO_2			Trace?	Trace?	Trace.
CO_2			.21	None.	None.
P_2O_5	.18	.30	.61	.36	Trace.
SO_3	.08	.17	.17		
S			.01	.02	Trace.
Cr_2O_3	Trace.	.03			
MnO	Trace.	.08	.13	.23	None.
SrO			.14	.02	.03
BaO	.02	.05	.28	.04	.10
Li_2O			Trace.	None.	Trace.
	99.91	100.55	100.06	100.38	100.25

O. Scoriaceous rhyolite, Mono Craters, south of Mono Lake. *Liparose.* Described by Russell in 8th Ann., pt. 1, p. 380. Analysis by T. M. Chatard, record No. 36.

P. Obsidian, Mono Lake. *Liparose.* Analysis by W. H. Melville, record No. 1346. Described by Lindgren in Bull. 150, p. 149. P. R. C. 60.

Q. Pumice, Mono Lake. *Toscanose.* Analysis by Melville, No. 1346. Described by Lindgren in Bull. 150, p. 148. P. R. C. 59.

R. Volcanic ash, east shore of Owens Lake. Collected and analyzed by Chatard, record No. 783.

S. Soda syenite, from near Coalinga, Fresno County. *II. 5.1.5.* Description supplied by E. S. Larsen. Contains plagioclase, hornblende, biotite, apatite, zircon, and iron ore, with secondary calcite, analcite, ægirite, and white mica. Analysis by W. F. Hillebrand, record No. 2366. Described by Ralph Arnold in Bull. 398. P. R. C. 1931.

T. Typical igneous rock, Ventura quadrangle. *Amadorose.* Received from J. R. Pemberton. No description furnished. Analysis by R. C. Wells, record No. 2449.

	O	P	Q	R	S	T
SiO_2	74.05	75.78	67.39	55.81	60.00	68.14
Al_2O_3	13.85	12.39	15.99	10.07	16.88	17.00
Fe_2O_3	Trace.	.22	.56	3.43	1.83	2.84
FeO		1.25	1.99	.67	3.02	.22
MgO	.07	.31	.77	2.22	1.40	1.07
CaO	.90	.81	1.63	1.05	3.16	3.83
Na_2O	4.60	4.00	4.74	.75	9.31	4.94
K_2O	4.31	4.64	4.80	2.98	.94	.83
H_2O-	2.20	.41	2.06	.65	.43	1.06
H_2O+				2.50	1.53	
TiO_2				.80	.42	.52
ZrO_2					.03	
CO_2					.59	
P_2O_5				.27	.14	
S					Trace.	
MnO				.23	.12	
BaO					.06	
SrO					.02	
Li_2O					Trace.	
$CaCO_3$				14.44		
NaCl, soluble				1.45		
Na_2SO_4, soluble				.80		
Na_2CO_3, soluble				2.09		
	99.98	99.81	99.93	100.21	99.88	100.45

OREGON.

1. BASALT, MOUNT THIELSEN.

Partly described by Diller in Am. Jour. Sci., 3d ser., vol. 28, p. 257. A hypersthene basalt containing hypersthene, olivine, feldspar, and magnetite. In the printed paper only the analysis of the groundmass and the fulgurite formed in it are given.

A. Hypersthene basalt.

B. Pyroxene.

C, D. Feldspars.

E. Groundmass.

F. A fulgurite, or lightning tube.

Analyses A and F by F. W. Clarke, record Nos. 108, 105; B, C, D, and E by T. M. Chatard, record Nos. 135, 133, 134, 128. These analyses were made early in the history of the laboratory and are by no means complete.

	A	B	C	D	E	F
SiO_2	55.68	53.31	55.48	51.95	55.85	55.04
Al_2O_3	18.93	5.99	26.91	28.84	22.95	28.99
Fe_2O_3	8.73	13.43	2.32	2.24	4.59	
FeO						
MgO	4.86	21.69	2.27	1.34	3.08	5.85
CaO	7.99	3.69	8.11	11.42	8.41	7.86
Na_2O	2.12		3.14	3.22	2.16	
K_2O	.48		.72	.59	2.67	
H_2O	.60		.66	.40	.52	1.11
TiO_2			.39	Trace.		
P_2O_5					Trace.	
	99.39	98.11	100.00	100.00	100.23	98.85

Iron oxides not separated. Analyses B, C, D, and F made on very small quantities of material. C and D were analyzed by the hydrofluoric-acid method, and the silica was determined by difference.

2. RIDDLES QUADRANGLE.

A. Peridotite, the matrix of the silicate nickel ores. Described by Diller and Clarke in Bull. 60, p. 21. The rock, which may be classed as saxonite, consists essentially of olivine and enstatite, with a little chromite and magnetite. Olivine predominates, and the enstatite forms less than one-third of the mass. Quartz, serpentine, and genthite are present as alteration products.

B. Olivine separated from A. Analyses A, B, by F. W. Clarke, record Nos. 811, 814.

C. Dacite porphyry, sec. 5, T. 30 S., R. 6 W. *Lassenose.*

D. Granodiorite, sec. 26, T. 30 S., R. 3 W. *Hessose.*

E. Intermediate rock, between greenstone and granodiorite, Evans Creek, near mouth of Sykes Creek. *Vaalose.*

F. Augite andesite, south bank Umpqua River, ½ mile west of Days Creek. *Auvergnose.*

Rocks C to F collected by G. F. Kay. Analyses by G. Steiger, record No. 2354.

	A	B	C	D	E	F
SiO_2	41.43	42.81	70.65	58.25	57.06	50.01
Al_2O_3	.04		15.57	20.52	8.50	15.25
Fe_2O_3	2.52	2.61	.57	.68	1.11	2.72
FeO	6.25	7.20	1.26	3.88	5.40	5.35
MgO	43.74	45.12	.48	2.03	11.19	9.35
CaO	.55	None.	3.28	7.88	12.04	10.44
Na_2O			4.91	4.25	1.39	1.50
K_2O			1.77	.50	.95	.60
H_2O-	[a] 4.41	[a] .57	.14	.24	.18	2.61
H_2O+			.86	1.10	1.25	1.35
TiO_2			.21	.57	.52	.68
ZrO_2			.01	.01	None.	None.
CO_2			Trace.	None.	None.	None.
P_2O_5			.07	.16	.05	.03
S			.07	None.	None.	None.
Cr_2O_3	.76	.79				
NiO	.10	.26				
MnO	None.	None.	.06	.10	.13	.12
BaO			.06	None.	Trace.	None.
SrO			Trace.	None.	None.	None.
	99.80	99.36	99.97	100.17	99.77	100.01

[a] Loss on ignition.

The four following rocks were also collected by Kay. Analyses by Steiger, record No. 2349:

G. Diabasic greenstone, sec. 2, T. 30 S., R. 6 W. *Beerbachose.*

H. Basaltic greenstone, sec. 23, T. 31 S., R. 6 W. *Koghose.*

I. Gabbroic greenstone, sec. 2, T. 34 S., R. 6 W.

J. Dioritic greenstone, sec. 29, T. 34 S., R. 6 W. *Ouenose.*

	G	H	I	J
SiO_2	50.90	52.58	45.86	46.36
Al_2O_3	16.71	15.58	15.52	16.88
Fe_2O_3	.40	2.07	1.84	2.23
FeO	8.50	6.68	3.22	6.29
MgO	5.14	5.75	11.71	8.15
CaO	9.74	10.37	15.57	15.66
Na_2O	3.50	1.79	.86	1.17
K_2O	.60	.82	.12	.10
H_2O-	.03	.22	1.38	.21
H_2O+	2.12	3.13	3.70	1.48
TiO_2	1.80	.89	.22	1.29
CO_2	.51	.22	None.	None.
P_2O_5	.07	.09	None.	Trace.
S	None.	None.	.06	.01
MnO	.13	.15	.07	.10
BaO	.02	.03	None.	None.
SrO	Trace.	Trace.	None.	None.
	100.17	100.37	100.13	99.93

ZrO_2 absent.

3. CRATER LAKE.

Rocks collected by J. S. Diller. All except the last one in the series are described by H. B. Patton in P. P. 3. Analyses A to N, inclusive, by H. N. Stokes, record Nos. 1671, 1953.

A. Vitrophyric rhyolite, south edge of Llao Rock flow. *Lassenose.* Contains plagioclase, hypersthene, hornblende, and apatite in a glassy groundmass crowded with augite microlites. P. R. C. 1314.

B. Streaked rhyolite, near "Wine Glass" Grotto Cove. *Lassenose.* Contains plagioclase, hypersthene, hornblende, and magnetite, with black glass. A few small inclusions of basalt and hypersthene andesite. P. R. C. 1316.

C. Rhyolite, small dike immediately below Llao Rock. *Lassenose.* Contains plagioclase, hornblende, hypersthene, and magnetite in a glassy groundmass crowded with microlites of feldspar and augite. P. R. C. 1317.

D. Rhyolite, water's edge, head of Cleetwood Cove. *Lassenose.* Contains plagioclase, hypersthene, brown hornblende, and magnetite, in a feldspathic groundmass of trachytic type. P. R. C. 1315.

E. Hypersthene-augite andesite, large dike transecting the northwestern portion of the crater rim. *Tonalose.* Contains plagioclase, hypersthene, augite, and magnetite in a groundmass having a moderate amount of glass. P. R. C. 1313.

F. Hypersthene-augite andesite, west edge of Wizard Island. *Tonalose.* Same minerals as E. P. R. C. 1309.

	A	B	C	D	E	F
SiO_2	70.77	68.17	71.78	70.10	60.09	59.39
Al_2O_3	14.83	15.60	14.53	15.18	17.85	18.45
Fe_2O_3	1.35	2.31	1.28	1.78	2.03	1.79
FeO	1.25	.94	1.02	1.09	3.45	3.90
MgO	.64	1.02	.48	.74	3.50	3.13
CaO	2.12	2.76	1.59	2.27	6.28	6.29
Na_2O	5.07	5.15	5.08	5.15	4.17	4.29
K_2O	2.68	2.46	2.84	2.58	1.31	1.29
H_2O-	.07	.09	.06	.10	.12	.10
H_2O+	.33	.45	.22	.19	.26	.42
TiO_2	.38	.54	.41	.48	.54	.41
P_2O_5	.13	.13	.10	.13	.23	.22
ZrO_2	.05	None.	.04	.04	None.	None.
NiO	None.	None.	None.	None.	.05	None.
SrO	.02	.03	.03	.03	.05	.04
BaO	.08	.06	.08	.08	.05	.05
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Cl	.11	Trace.	Trace.	.03	Trace.	Trace.
	99.88	99.71	99.63	99.97	99.98	99.77

Traces of manganese in all. Fluorine not sought for. No CO_2, S, SO_3, or Cr_2O_3 in any.

G. Hypersthene-augite andesite, crater rim, just south of "The Watchman." *Tonalose.* Same minerals as F. P. R. C. 1310.

H. Hypersthene-augite andesite, Palisades, under Round Top, northeast portion of the rim. *Tonalose.* Contains plagioclase, hypersthene, augite, and magnetite. P. R. C. 1312.

I. Hypersthene-augite andesite, lake level, under Llao Rock. *Tonalose.* Same minerals as H. P. R. C. 1311.

J. Basalt, base of Red Cone. *Andose.* Contains plagioclase, augite, olivine, and magnetite, with some glass base. P. R. C. 1321.

	G.	H	I	J
SiO_2	60.98	62.09	58.41	52.99
Al_2O_3	17.82	17.03	17.85	16.71
Fe_2O_3	1.83	2.38	2.67	3.80
FeO	3.33	2.69	3.29	3.55
MgO	2.76	3.08	3.61	6.95
CaO	5.73	5.65	6.81	8.49
Na_2O	4.26	4.10	3.77	3.56
K_2O	1.43	1.67	1.23	1.29
H_2O-	.13	.04	.34	.18
H_2O+	.45	.13	.86	.59
TiO_2	.71	.65	.69	1.18
P_2O_5	.17	.19	.24	.42
NiO	None.	None.	None.	.02
MnO	Trace.	Trace.	Trace.	Trace.
SrO	.05	.07	.05	.12
BaO	.06	.07	.05	.07
Li_2O	None.	None.	Trace.	None.
Cl	Trace.	Trace?	Trace.	Trace.
	99.71	99.84	99.87	99.92

K. Hypersthene basalt, Anna Creek. *Andose-beerbachose.* Contains plagioclase, augite, hypersthene, olivine, and magnetite. P. R. C. 1320.

L. Hypersthene basalt of andesitic type, north of Desert Cove. *Tonalose.* Contains plagioclase, hypersthene, augite, and olivine.

M. Dark secretion from among dacitic ejectamenta, summit of Llao Rock. *Tonalose-andose.* Contains plagioclase, hornblende, hypersthene, and augite, with a little olivine and apatite, in a dark-brown glassy groundmass. P. R. C. 1318.

N. Light-colored secretion from among dacitic ejectamenta, southern rim of crater, between Sand and Anna creeks. *Lassenose.* Contains plagioclase, hypersthene, augite, hornblende, biotite, and quartz. P. R. C. 1319.

O. Basalt, 1 mile east of the summit of the Cascade Range, on the road from Fort Klamath to Crater Lake. *Beerbachose.* Described by J. S. Diller as a typical basalt, carrying a considerable amount of hypersthene. Analysis by W. F. Hillebrand, record No. 408.

	K	L	M	N	O
SiO_2	56.95	58.65	56.85	67.41	57.47
Al_2O_3	18.84	18.35	18.31	15.76	18.86
Fe_2O_3	2.06	1.59	2.88	1.88	2.21
FeO	4.28	4.21	3.15	1.76	4.08
MgO	4.37	3.49	3.92	1.35	4.27
CaO	7.45	6.95	7.20	3.36	7.42
Na_2O	3.89	3.70	3.89	4.54	3.85
K_2O	.82	1.32	1.23	2.36	.73
H_2O-	.19	.20	.16	.09	.22
H_2O+	.31	.70	.95	.54	
TiO_2	.79	.81	1.08	.56	.75
P_2O_5	.19	.17	.22	.12	.24
S	Trace.	None.	None.	.02	....
MnO	Trace.	Trace.	Trace.	Trace.	.10
BaO	.04	.06	.04	.06	.03
SrO	Trace.	Trace.	Trace.	Trace.	.11
	100.18	100.20	99.88	99.81	100.34

CO_2, Cr_2O_3, and Li_2O were absent from all five.

4. PORT ORFORD QUADRANGLE.

Rocks collected by J. S. Diller and partly described by him in Folio 89. Analysis A by George Steiger, record No. 1892. B, D, E, F, by H. N. Stokes, record No. 1891. C, G, H, I, J, K, L, M, by W. F. Hillebrand, record No. 1897.

A. Serpentine, from 12 miles north of mouth of Boulder Creek.

B. Serpentine, from Iron Mountain crest. Contains, with serpentine, olivine, pyroxene, sometimes hornblende, and magnetite, with picotite or chromite.

C. Metagabbro, southeast slope of Panther Mountain. *Hessose*. Much altered. Contains plagioclase and pale-green fibrous hornblende. Fine scales of mica and groups of epidote are also common.

D. Normal metagabbro, summit of Bald Mountain. *Auvergnose*. Contains plagioclase, hornblende, numerous grains of magnetite or ilmenite, and traces apparently of pyroxene.

	A	B	C	D
SiO_2	39.42	38.55	44.19	50.14
Al_2O_3	1.39	1.32	20.66	15.26
Fe_2O_3	3.42	5.55	.52	1.19
FeO	4.29	2.17	3.26	8.75
MgO	39.68	39.06	11.90	7.21
CaO	1.10	.85	10.76	9.34
Na_2O	None.	.10	1.35	2.76
K_2O	None.	.05	1.03	.95
H_2O-	.36	1.14	.74	.23
H_2O+	9.53	10.14	5.19	2.22
TiO_2	None.	Trace.	.12	1.42
ZrO_2	....	....	None.	....
CO_2	....	.51	.06	None.
P_2O_5	None.	Trace.	Trace.	.24
S	....	.03	Trace.	.04
Cr_2O_3	.58	.48	.15	Trace.
NiO	....	.13	.03	....
MnO	Trace.	.05	.11	Trace.
BaO	None.	None.	.04	.03
SrO	....	None.	.05	None.
Li_2O	....	Trace.	(?)	None.
	99.77	100.13	100.16	99.78

E. Gabbro, Brush Creek, 1½ miles southwest of Bald Mountain. *Yellowstonose*. Rich in quartz and feldspar, with subordinate biotite and hornblende. Contains some chlorite.

F. Gabbro, west of Brush Creek, near summit of Mussel Creek divide. *SR. 5 of kilauase*. Chiefly feldspar and pyroxene, the latter partly changed to hornblende. A little quartz is present.

G. Gabbro, left bank of Rogue River, 2 miles below the mouth of Illinois River. *SR. 5 of monzonase*. Consists mainly of plagioclase and hornblende.

H. Basalt, Cedar Creek, 1½ miles northeast of Ophir. *Auvergnose*. Consists mainly of hornblende and feldspar. Grains of pyroxene are present, and a black dust which appears to be magnetite.

I. Basalt, near fork of West Bend trail, 2½ miles south of Johnson Creek. *Beerbachose*. Contains plagioclase and pyroxene, with secondary chlorite and hornblende.

	E	F	G	H	I
SiO_2	60.88	56.45	57.43	50.56	52.12
Al_2O_3	17.71	13.81	17.69	14.49	15.21
Fe_2O_3	2.92	1.73	1.59	1.78	1.83
FeO	2.17	3.95	3.48	10.20	8.95
MgO	2.21	8.67	2.73	5.90	6.01
CaO	4.32	6.69	5.72	10.13	3.75
Na_2O	4.17	5.03	7.19	2.91	4.83
K_2O	2.68	.46	.58	.38	.48
H_2O-	.54	.67	.48	.20	.90
H_2O+	1.47	2.02	1.81	1.50	3.74
TiO_2	.41	.31	.66	1.67	1.38
ZrO_2	....	....	None.	None.	None.
P_2O_5	.16	.02	.17	Trace.	.14
CO_2	None.	None.	.10	(?)	.09
Cr_2O_3	None.	Trace.	....	....	None.
NiO	....	....	....	Trace.	.03
S	Trace.	Trace.	.02	....	Trace.
FeS_2	....	....	....	.28	....
MnO	Trace.	Trace.	.17	.25	.19
BaO	.06	Trace.	None.	Trace.	Trace.
SrO	Trace.	.02	.02	None.	None.
	99.70	99.83	99.84	100.25	99.65

J. Basalt, Sawtooth Rock. *I. 5. 3. 5.* Largely feldspar and pyroxene, with some quartz.

K. Dacite porphyry, 6 miles west of Big Bend of Rogue River. *Kallerudose.* Contains plagioclase and quartz, with some orthoclase, and scattered patches of chlorite and hornblende.

L. Dacite porphyry, head of Boulder Creek. *Yellowstonose.* Contains abundant quartz, altered feldspar, grains of epidote, hornblende, and chlorite.

M. Dacite porphyry, south slope of Bald Mountain. *Alsbachose-lassenose.*

	J	K	L	M
SiO_2	53.06	71.45	70.33	75.32
Al_2O_3	12.83	14.53	15.74	13.17
Fe_2O_3	1.20	.49	1.43	.27
FeO	5.10	.94	.83	.98
MgO	7.50	.30	.53	.42
CaO	13.71	2.01	3.38	1.48
Na_2O	3.56	7.15	4.33	4.77
K_2O	.05	2.55	1.87	2.14
H_2O-	.16	.15	.20	.18
H_2O+	2.16	.38	1.16	.73
TiO_2	.42	.16	.27	.16
CO_2	.25	.08	Trace.	.03
ZrO_2	Trace?	Trace.	None.	None.
P_2O_5	Trace.	.09	.06	.04
S	Trace.	Trace.	Trace.	....
FeS_2	....	....	....	.09
MnO	.16	Trace.	Trace.	Trace.
BaO	None.	.03	.09	.23
SrO	None.	None.	Trace.	.02
Cr_2O_3	.06	....	....	....
NiO	Trace.	....	....	....
	100.22	100.31	100.22	100.03

5. MISCELLANEOUS ROCKS.

A. Normal granodiorite from near lake at base of Bald Mountain, northwest of Sumpter. *Yellowstonose.* Described by Lindgren in 22d Ann., Part II, p. 587. Contains quartz, hornblende, andesine, orthoclase, biotite, and magnetite. Slight alterations to epidote and chlorite are sometimes noticeable. Analysis by W. F. Hillebrand, record No. 1896. P. R. C. 1529.

B. Rock from Wilbur, Douglas County. A tuff partly of igneous, partly of organic, origin. The igneous matter contains a few grains of feldspar and augite, with particles of a rock like diabase. The organic remains are partly calcareous and partly siliceous. Description supplied by J. S. Diller. Analysis by H. N. Stokes, record No. 1737.

C. Basaltic tuff, Columbia River, 25 miles east of Portland. Described by Diller in Bull. 260, p. 343. Analysis by G. Steiger, record No. 2165.

	A	B	C
SiO_2	71.23	55.15	40.89
Al_2O_3	14.61	[a] 9.75	10.41
Fe_2O_3	.93	7.76	15.00
FeO	1.66	....	.07
MgO	1.01	2.22	3.76
CaO	3.29	10.48	5.18
Na_2O	4.00	1.00	.47
K_2O	1.92	.50	.53
H_2O-	.17	2.70	9.14
H_2O+	.55	6.59	10.32
TiO_2	.34	....	3.37
CO_2	....	3.64	None.
ZrO_2	.02	....	....
P_2O_5	.14	....	.52
S	Trace.	....	.03
MnO	.08	....	.90
V_2O_3	....	....	.01
BaO	.08	....	....
SrO	.02	....	....
Li_2O	Trace.	....	....
	100.05	99.79	100.60

[a] Includes TiO_2 and P_2O_5, if present.

WASHINGTON.

1. MOUNT STUART QUADRANGLE.

Rocks described by George Otis Smith, in Folio 106. Analyses A, B, C, F, and G by H. N. Stokes, record No. 1836; D, E, H, and I by W. F. Hillebrand, record No. 1831; J by George Steiger, record No. 2046.

A. Granodiorite, south slope of Mount Stuart. *Tonalose*. Contains plagioclase, orthoclase, hornblende, biotite, quartz, and magnetite. P. R. C. 1407.

B. Granodiorite, ridge between Hardscrabble and Cascade creeks. *Tonalose*. Contains plagioclase, orthoclase, biotite, hornblende, quartz, magnetite, and apatite. P. R. C. 1412.

C. Granodiorite porphyry, dike 2 miles west of Mount Stuart. *Tonalose*. Contains plagioclase, biotite, hornblende, orthoclase, and quartz. P. R. C. 1414.

D. Serpentine, Three Brothers. Derived from saxonite. Contains serpentine, bastite, magnetite, and pyrite. P. R. C. 1408.

E. Metamorphic rock, head of Beverly Creek. "Nickel Ledge." Believed to be derived from an inclusion of limestone in the peridotite. P. R. C. 1410.

	A	B	C	D	E
SiO_2	64.04	63.37	63.78	39.00	32.12
Al_2O_3	15.58	15.90	16.39	1.75	.82
Fe_2O_3	1.26	1.41	1.12	5.16	2.05
FeO	3.22	3.18	2.76	1.71	3.50
MgO	3.23	3.33	3.27	38.00	26.73
CaO	4.51	4.63	4.07	Trace.	1.81
Na_2O	4.01	4.05	3.84	.10	.06
K_2O	2.22	2.10	2.03		
H_2O-	.19	.18	.22	1.31	.43
H_2O+	1.17	1.16	1.82	12.43	.98
TiO_2	.69	.69	.44	Trace.	Trace.
P_2O_5	.16	.17	.11	Trace.	Trace.
Cr_2O_3	None.	None.	None.	.47	.27
NiO	None.	None.	None.	.10	.08
MnO	Trace.	Trace.	.05	.15	.14
SrO	Trace.	None.	Trace.	None.	None.
BaO	.11	.06	.08	None.	None.
Li_2O	Trace.	Trace.	Trace.	None.	....
CO_2	None.	None.	None.	None.	31.04
S	Trace.	Trace.	Trace.	....	....
FeS_2[a]	....	....	....	.03	None.
	100.39	100.23	99.98	100.21	100.03

[a] Actual condition of sulphur not known.

F. Gabbro, east of Beverly Creek. *Hessose*. Contains diallage and "basic" plagioclase, with pyrite and serpentine as alteration products. P. R. C. 1411.

G. Gabbro, Camas Land. *Hessose*. Contains augite, olivine, plagioclase, magnetite, and apatite. P. R. C. 1413.

H. Diabase, dike on ridge west of Turnpike Creek. *Tonalose*. Contains plagioclase, augite, olivine, magnetite, and apatite. P. R. C. 1406.

I. Basalt, middle fork of Teanaway River. *Vaalose*. Contains augite, plagioclase, magnetite, and apatite, with a glassy base. P. R. C. 1409.

J. Yakima basalt, Clealum Ridge. *Andose*. Contains plagioclase, augite, olivine, magnetite, apatite, and glass. P. R. C. 1405.

	F	G	H	I	J
SiO_2	48.58	51.98	57.21	53.35	54.50
Al_2O_3	20.23	15.99	12.99	12.90	14.43
Fe_2O_3	1.26	3.10	3.28	2.64	2.17
FeO	3.02	5.88	10.18	11.28	8.80
MgO	7.59	5.09	1.59	2.68	4.24
CaO	14.01	9.68	5.97	6.96	8.01
Na_2O	2.25	2.71	3.07	2.83	3.05
K_2O	.19	.81	1.61	1.40	1.29
H_2O-	.28	.48	.68	.91	.29
H_2O+	2.68	2.08	1.03	1.76	1.09
TiO_2	.09	1.71	1.72	2.44	1.69
P_2O_5	Trace.	.31	.44	.45	.21
Cr_2O_3	Trace.	None.	None.	None.	....
V_2O_3	....	....	None.	.04	....
MnO	Trace.	.10	.24	.25	.10
NiO	None.	None.	Trace.	Trace.	None.
SrO	None.	None.	Trace.	Trace.	.09
BaO	None.	.03	.06	.05	.06
Li_2O	None.	Trace.	Trace.	Trace.	....
FeS_2	....	....	.13	.13	....
S	.10	.01	....	....	....
SO_3	....	....	....	....	.11
	100.25	99.96	100.20	100.07	100.13

2. SNOQUALMIE QUADRANGLE.

Rocks described by Smith and Calkins in Folio 139. Analyses by G. Steiger, record No. 2145.

A. Rhyolite, near Easton. *Alaskose.* Contains albite, quartz, magnetite, zircon, and apatite, with a little secondary kaolin, sericite, and limonite.

B. Hypersthene andesite, Naches Valley. *Tonalose.* Contains plagioclase, hypersthene, augite, magnetite, and apatite.

C. Granodiorite, head of Gold Creek. *Tonalose.* Contains plagioclase, orthoclase, quartz, hornblende, biotite, apatite, zircon, magnetite, and titanite.

D. Basalt, 2 miles south-southeast of Naches Pass. *Auvergnose.* Contains plagioclase, olivine, augite, magnetite, apatite, and very little glass.

	A	B	C	D
SiO_2	76.17	62.77	60.49	50.36
Al_2O_3	12.32	14.96	17.77	15.83
Fe_2O_3	1.47	1.62	1.98	2.29
FeO	.20	4.36	3.29	8.11
MgO	None.	1.48	2.94	7.90
CaO	.17	3.90	6.20	9.25
Na_2O	3.94	4.31	3.67	3.05
K_2O	4.27	2.13	1.37	.86
H_2O-	.23	.51	.27	.05
H_2O+	.79	2.49	1.13	.27
TiO_2	.20	.79	.69	1.33
ZrO_2	.03	.03	.02	....
P_2O_5	.04	.22	.08	.21
MnO	None.	.10	.09	.24
BaO	.10	.10	.04	Trace.
SrO	....	None.	.02	Trace.
(CoNi)O	None.	None.	Trace.	None.
	99.93	99.77	100.05	99.75

CO_2, S, and SO_3 absent.

3. MISCELLANEOUS ROCKS.

A. Minette. Dike, west bank of Columbia River, 1 mile above Northport. *Washingtonose*. Collected by F. L. Ransome, who furnishes the petrographic description. Analysis by W. F. Hillebrand, record No. 1988. Contains orthoclase, possibly some plagioclase, abundant biotite, pyroxene, apatite, and titanite. P. R. C. 1699.

B. Brucite-serpentine rock, from quarry of the United States Marble Co., 12 miles north and west of Valley, Stevens County. Resembles ordinary serpentine, but contains also brucite, chlorite, and hydromagnesite. The brucite amounts to about 60 per cent. Described by Clarke in Am. Jour. Sci., 4th ser., vol. 15, p. 397. Analysis by George Steiger, record No. 2009. P. R. C. 340.

C. Matrix of dumortierite, north fork of Washougal River, Skamania County. Analyzed and described by W. T. Schaller, Bull. 262, p. 105. Contains andalusite, quartz, muscovite, a little dumortierite, and accessory pyrite, magnetite, possibly ilmenite, leucoxene, and apatite. A little B_2O_3 present, undetermined.

	A	B •	C
SiO_2	41.57	13.08	57.18
Al_2O_3	9.75	1.63	34.10
Fe_2O_3	4.06	1.25	.54
FeO	4.47	.19	.28
MgO	8.65	56.44	.10
CaO	11.10	.33	.63
Na_2O	1.57	None.	.39
K_2O	6.10	None.	2.57
H_2O-	1.54	.85	.69
H_2O+	2.30	23.94	2.02
TiO_2	2.36	Undet.	.66
ZrO_2	.02	....	.02
CO_2	1.24	2.03	None.
P_2O_5	4.05	Undet.	.53
Cl	.04	....	....
F	.23	....	....
FeS_2	.06	....	.28
Cr_2O_3	.04	....	None.
NiO	.02	....	None.
MnO	.25	....	None.
BaO	.44	....	.04
SrO	.11	....	Trace.
Li_2O	Trace.	....	None.
V_2O_3	.04	....	....
	100.01	99.74	100.03
Less O=Cl, F	.11	....	....
	99.90	....	....

ALASKA.

1. DOUGLAS ISLAND.

A. Diorite, Treadwell mine, Douglas Island. *Tuolumnose*. Contains plagioclase, mostly albite, with secondary quartz, calcite, and pyrite, the latter apparently replacing ferromagnesian silicates. Described by G. F. Becker in 18th Ann., pt. 3, p. 7. Analysis by W. F. Hillebrand, record No. 1585.

B. Albite diorite, Treadwell mine. Contains plagioclase, a little microperthite, hornblende, epidote, calcite, and pyrite.

C. Albite diorite, Treadwell mine. *Akerose*. Like B, but with sericite, more microperthite, and no hornblende.

D. Altered diorite. Contains calcite, biotite, chlorite, quartz, and pyrrhotite.

E. Amphibolite. *Auvergnose*.

Rocks B to E described by A. C. Spencer in Bull. 287. Analyses by G. Steiger, record No. 2168.

	A	B	C	D	E
SiO_2	63.01	64.36	58.53	44.69	47.76
Al_2O_3	18.47	18.18	17.74	14.97	13.98
Fe_2O_3	.06	.64	1.58	.60	1.99
FeO	.32	.43	1.46	7.05	8.72
MgO	.06	.28	1.71	3.92	9.07
CaO	2.66	2.56	5.06	10.07	12.71
Na_2O	10.01	8.96	5.69	2.36	1.65
K_2O	.39	.89	3.90	1.76	.20
H_2O-	.05	.18	.18	.36	.22
H_2O+	.27	.55	1.18	.20	2.06
TiO_2	.13	.17	.81	2.25	1.48
ZrO_2	....	.03	.06	.02	None.
CO_2	2.01	1.62	.90	8.47	None.
P_2O_5	.06	.06	.27	.26	.12
SO_3	....	.07	None.	None.	None.
S	....	....	....	....	.04
V_2O_3	.01	....	....	....	....
MnO	.06	.11	.11	.14	.14
BaO	.02	.06	.07	.14	Trace.
SrO	Trace.	.04	.05	Undet.	None.
Fe_7S_8	....	....	....	2.25	....
FeS_2	2.10	.97	.96	.27	....
	99.69	100.16	100.28	99.78	100.14

2. EAGLE RIVER REGION.

Rocks described by A. Knopf in Bull. 502.

A. Albite diorite, Boston mine, Juneau. *Andose.* Contains plagioclase near Ab_{95} An_5, orthoclase, microperthite, biotite, apatite, titanite, and magnetite, with secondary chlorite, sericite, zoisite, and epidote.

B. Zoisite amphibolite, Crystal mine, Port Snettisham. Contains amphibole, zoisite, epidote, albite, ilmenite, titanite, chlorite, and muscovite.

C. Amphibolite, Mendenhall Glacier. *Camptonose* near *Auvergnose.* Contains amphibole, zoisite, epidote, albite, and biotite. Sp. gr. 3.084.

D. Altered amphibolite, Mendenhall Glacier. *Andose.* Sp. gr. 2.908. Analyses by J. G. Fairchild, record Nos. 2559, 2567.

	A	B	C	D
SiO_2	49.64	46.87	48.30	52.92
Al_2O_3	19.78	15.14	13.59	20.53
Fe_2O_3	1.89	3.87	3.12	Trace.
FeO	4.76	8.41	10.44	8.38
MgO	3.33	6.10	6.29	2.43
CaO	6.77	11.27	11.09	4.76
Na_2O	4.83	3.02	2.16	4.67
K_2O	1.95	.30	1.55	2.96
H_2O-	.02	None.	None.	.18
H_2O+	2.65	2.23	2.06	1.58
TiO_2	3.53	2.20	1.01	.99
P_2O_5	.67	.15	.26	.57
MnO	.17	.17	.25	.28
	99.99	99.73	100.12	100.25

CO_2 and S absent.

3. COPPER RIVER BASIN.

Andesites, described by W. C. Mendenhall in P. P. 41. Analyses A, B, by W. F. Hillebrand, record No. 2075. C, D, by George Steiger, record No. 2080.

A. Dark, vesicular, porphyritic lava, late eruption, Mount Wrangell. *Tonalose.* Contains labradorite, hypersthene, olivine, and magnetite in a brown glassy base. Collected by Mendenhall.

B. Gray, porphyritic, well-crystallized older lava, Mount Drum. *Tonalose.* Contains plagioclase, hornblende, biotite, hypersthene, magnetite, apatite, and zircon in a fine gray hypocrystalline base. Collected by Mendenhall.

C. Augite andesite, lower north slope of Mount Sanford. *Kallerudose.* Contains plagioclase, augite, and magnetite in a microcrystalline groundmass of the same minerals. Collected by F. C. Schrader.

D. Hypersthene andesite from near C. *Lassenose.* Contains plagioclase, hornblende, hypersthene, and magnetite in a glassy groundmass of mainly plagioclase and hypersthene. Collected by Schrader.

	A	B	C	D
SiO_2	61.31	62.67	70.94	67.04
Al_2O_3	16.70	16.62	13.96	16.71
Fe_2O_3	1.30	3.25	1.74	1.46
FeO	4.08	1.17	1.69	2.08
MgO	3.44	3.08	.12	1.09
CaO	6.10	5.56	1.13	3.26
Na_2O	4.05	4.24	5.64	5.07
K_2O	1.58	1.67	4.03	1.84
H_2O-	.22	.23	.09	.08
H_2O+	.36	1.01	.45	.51
TiO_2	.73	.48	.30	.51
ZrO_2	.01	.01	.05	.05
P_2O_5	.18	.15	.10	.27
NiO	.02	.01	None.	None.
MnO	.14	.11	.15	.16
BaO	.05	.06	.06	.03
SrO	.02	.03	Trace.	Trace.
Li_2O	Trace?	Trace.	....	....
	100.29	100.35	100.45	100.16

CO_2 and S absent.

4. PRINCE OF WALES ISLAND.

Rocks described by C. W. Wright in P. P. 87. Petrographic determinations by H. E. Merwin.

A. Diorite, Jumbo Basin, Copper Mountain. *Andose.* Contains quartz, plagioclase, orthoclase, hornblende, and augite, with accessory biotite, apatite, titanite, and magnetite. Analysis by G. Steiger, record No. 2441.

B. Altered diorite, Jumbo mine.

C. Contact rock, Jumbo mine. Analyses B, C, by R. C. Wells, No. 2681.

D. Diopside orthoclasite, shore of Hetta Inlet. *Hettose.* Contains orthoclase (about 90 per cent) and diopside, with accessory albite, titanite, and apatite. Analysis by C. Palmer, No. 2474.

E. Calcite-syenite porphyry, dike near head of Karta Bay, Kasaan Peninsula. *Nordmarkose.* Contains alkali feldspar, calcite, quartz, muscovite, apatite, zircon, and rutile. Analysis by Wells, No. 2511.

F. Contact rock, Mamie mine, 1¼ miles southeast of Hadley. Contains plagioclase, orthoclase, epidote, and calcite. Analysis by Steiger, No. 2441.

	A	B	C	D .	E	F
SiO_2	59.44	46.57	39.51	62.03	63.41	58.87
Al_2O_3	17.40	13.51	5.87	16.39	16.86	17.12
Fe_2O_3	3.30	2.92	8.54	.72	None.	1.96
FeO	2.77	2.73	3.40	.86	2.88	.95
MgO	1.81	2.85	5.08	1.60	Trace.	1.75
CaO	6.51	19.92	29.42	3.60	1.47	8.00
Na_2O	4.22	2.33	1.00	1.08	7.38	4.64
K_2O	3.12	2.52	.64	12.38	3.09	4.34
H_2O-	.06	.33	.33	.24	.29	.13
H_2O+	.56	.53	.62	.61	.42	.81
TiO_2	.66	.64	.29	.53	.26	.59
ZrO_2	None.				.04	None.
CO_2	None.	3.40	3.68		2.93	.84
P_2O_5	.28	.27	.07	.13	.12	.20
F	Trace?					Trace?
S	.02				.05	.09
SO_3		Trace.			None.	
MnO	.17	.40	.62		.28	.10
BaO	.07				None.	.06
SrO	.05					.02
FeS_2			.64			
MoS_2		.78				
	100.44	99.70	99.71	100.17	99.48	100.47

5. MISCELLANEOUS ROCKS.

Rocks A to G, inclusive, were collected by G. F. Becker, who furnishes the petrographic data. A, B, C, D, and F are described by Becker in 18th Ann., pt. 3, p. 7. Analyses by Hillebrand, record No. 1585.

A. Augite-bronzite andesite, Delarof Harbor, Unga Island. *Andose.* Greenish black. Contains plagioclase near labradorite, with much smaller proportion of augite and bronzite, in a groundmass of plagioclase, with a little glass and much light-green indeterminate material.

B. Augite-bronzite andesite, St. Augustine Volcano, Cook Inlet. *Placerose.* Purplish gray. Contains labradorite, augite, and bronzite in a groundmass of plagioclase and magnetite.

C. Quartz porphyry, bed of Bear Creek, 4 miles from its mouth, Turnagain Arm, Cook Inlet. *Dacose.* Resembles D, with more feldspar and less quartz.

D. Quartz porphyry, east of mouth of Indian River, Sitka, Baranof Island. *Sitkose.* Contains plagioclase, quartz, a little pyroxene, and some carbonaceous matter, with secondary quartz, calcite, and muscovite.

E. Diorite, head of Captains Bay, Unalaska Island. *Tonalose.* Contains plagioclase, biotite, hornblende, chlorite, magnetite, and sometimes tourmaline.

	A	B	C	D	E
SiO_2	56.63	60.40	62.92	65.94	58.63
Al_2O_3	16.85	16.85	14.29	13.74	16.23
Fe_2O_3	3.62	1.88	.84	.49	1.91
FeO	3.44	3.72	4.66	5.21	4.20
MgO	4.23	3.82	3.14	2.33	4.28
CaO	7.53	7.25	2.72	2.87	6.59
Na_2O	3.08	3.80	4.30	2.80	3.51
K_2O	2.24	.77	1.39	1.63	2.09
H_2O-	.80	.09	.22	.21	.15
H_2O+	.51	.20	2.84	2.59	1.17
TiO_2	.67	.61	.84	.80	.74
P_2O_5	.16	.16	.13	.21	.20
V_2O_3	.04				
NiO	Trace?	.02	Trace.	Trace?	.02
MnO	.23	.12	.15	.11	.11
SrO	Trace.	Trace.	Trace.	Trace?	Trace.
BaO	.09	.06	.10	.12	.06
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.
CO_2	None.	None.	1.24	.59	None.
C				.20	
FeS_2	.06	.08	.32	.41	.04
	100.18	99.87	100.10	100.25	99.93

F. Diorite, Karluk Cliffs, Kodiak Island. *Bandose.* Contains labradorite and hornblende, with subordinate quartz, biotite, and magnetite.

G. Diorite, Lane & Hayward mine, Silverbow Basin. *Shoshonose.* Contains plagioclase, biotite, hornblende, and scattering grains of quartz, with secondary chlorite, epidote, and muscovite.

H. Hornblende andesite, Bogoslof Island. *Andose.* Described by Merrill in Proc. U. S. Nat. Mus., vol. 8, p. 31. Contains hornblende, augite, plagioclase, tridymite, grains of iron ore, a little apatite, and probably sanidine. P. R. C. 315.

I. Like H, but darker colored. *Andose.* Contains more hornblende, no glass, and little or no tridymite. Same locality, also described by Merrill. Analyses H and I by T. M. Chatard, record Nos. 209, 210. P. R. C. 316.

	F	G	H	I
SiO_2	61.58	54.20	56.07	51.54
Al_2O_3	15.89	15.86	19.06	20.31
Fe_2O_3	2.19	3.32	5.39	4.64
FeO	5.50	4.14	.92	3.56
MgO	2.69	3.51	2.12	3.16
CaO	6.49	5.32	7.70	9.55
Na_2O	3.04	3.28	4.52	4.29
K_2O	.51	3.30	1.24	2.47
H_2O-	.16	.55	.99	.34
H_2O+	1.26	2.40		
TiO_2	.63	1.35	1.24	.32
P_2O_5	.12	.68	.16	.57
V_2O_3	....	....	....	....
NiO	Trace?	.02	....	....
MnO	.20	.19	.23	.32
SrO	Trace?	.04	....	....
BaO	.06	.41	....	....
Li_2O	Trace.	Trace.	....	....
CO_2	None.	1.45	....	....
FeS_2	.06	.26	....	....
	100.38	100.28	99.64	101.07

Rocks J to R collected by J. E. Spurr. Rocks J to P are described by him in Am. Geologist, vol. 25, p. 210. Analyses by H. N. Stokes, record Nos. 1809 and 1822.

J. Alaskite, Chilkoot Pass. *Liparose.* Dike in granite. Contains quartz, orthoclase, and some twinned feldspars, accessory zircon, actinolite, magnetite, and siderite. P. R. C. 1784.

K. Alaskite porphyry, Fortymile Creek, near Canyon Creek. *Lassenose.* Dike. Contains quartz, orthoclase, and some plagioclase, with accessory biotite and epidote. P. R. C. 1785.

L. Alaskite, Skwentna River, 12 miles above its mouth. *Toscanose.* Dike. Contains quartz, orthoclase, and microcline, with no dark minerals.

M. Alaskite, Tordrillo Mountains. *Alaskose.* Dike. Consists of quartz, orthoclase, and microcline, with no dark minerals. P. R. C. 1275.

	J	K	L	M
SiO_2	76.30	67.01	75.01	77.33
Al_2O_3	12.50	17.91	13.88	12.55
Fe_2O_3	1.47	1.30	.74	.91
FeO				
MgO	None.	.42	.09	.10
CaO	.17	1.86	1.00	.17
Na_2O	3.86	5.33	3.52	3.19
K_2O	4.67	4.56	4.89	4.80
H_2O-	.18	.16	.11	.15
H_2O+	.32	.48	.26	.53
TiO_2	.05	.10	.06	.09
BaO	.07	.60	.10	Trace.
SrO	None.	.13	Trace.	Trace.
Li_2O	None.	None.	Trace.	Trace.
	99.59	99.86	90.66	99.82

In J to M there are traces of P_2O_5 but no CO_2. Manganese is also present in traces.

N. Augite belugite, Skwentna River, near Hayes River. *Hessose.* Dike. Contains essential feldspar, intermediate between andesine and labradorite, augite, and some hornblende. Also a considerable amount of pyrite. P. R. C. 1274.

O. Tordrillite, Tordrillo Mountains. *Alaskose.* Dike. Contains phenocrysts of quartz, orthoclase, anorthoclase, and anorthoclase-albite. Groundmass consists of quartz and orthoclase. No dark minerals except very small quantities of secondary hornblende. P. R. C. 1276.

P. Augite aleutite, near Kalinai Pass, Aleutian Peninsula. *Andose.* Lava. Chiefly labradorite, tending toward andesine, with a considerable amount of pale-green augite. P. R. C. 1277.

Q. Plagioclase-quartz-biotite rock, Skwentna River, 12 to 15 miles above its mouth *Tonalose.* Dike. Described by Spurr in Am. Jour. Sci., 4th ser., vol. 10, p. 310. Corrected in vol. 25, p. 154. Essential constituents andesine-oligoclase, quartz, and biotite, with accessory apatite and zircon. P. R. C. 1273.

R. Tonalite-aplite or yukonite. *Yukonose.* Yukon River, above Fort Hamlin. Consists essentially of quartz and soda-lime feldspars.

S. Flinty rock, Bonanza mine, Latouche Island, Prince William Sound. *II. 1. 2. 4.* Described by Grant and Higgins in Bull. 443. Contains mainly quartz, chlorite, and plagioclase. Analysis by R. C. Wells, record No. 2413.

T. Pumice, Katmai Volcano, eruption of 1912. *Alsbachose.* Received from G. C. Martin. Analysis by G. Steiger, record No. 2753.

	N	O	P	Q	R	S	T
SiO_2	50.23	75.84	56.03	62.78	74.79	79.40	76.91
Al_2O_3	19.46	13.38	18.31	17.16	12.59	6.11	12.18
Fe_2O_3	4.21	1.45	3.47	1.96	1.19	.16	.48
FeO	4.20		4.42	2.31		5.18	.92
MgO	3.59	.10	3.64	2.32	.31	4.13	None.
CaO	10.39	.07	7.43	4.84	3.58	.29	.92
Na_2O	3.08	3.33	3.60	4.11	5.10	.42	4.17
K_2O	1.32	4.73	1.18	2.15	.21	.19	3.15
H_2O-	.16	.18	.12	.24	.09	.15	.24
H_2O+	1.01	.71	.31	.88	1.03	2.75	.66
TiO_2	1.30	.09	1.24	.56	.17	.33	.18
CO_2	.25	None.	None.	None.	.58	None.	....
P_2O_5	.41	Trace.	.13	.15	Trace.	None.	None.
MnO	.07	Trace.	.11	.06	Trace.	.15	....
BaO	.04	Trace.	Trace.	.04	None.	None.	....
SrO	Trace.	Trace.	Trace.	Trace.	None.	....	....
Li_2O	Trace.	Trace.	Trace.	Trace.	None.	....	....
S	.02	....	Trace.	.02	....	....	None.
Cl	....	....	....	Trace.	....	....	....
FeS_2	....	....	....	....	....	.30	....
$FeCuS_2$	....	....	....	....	....	.72	....
Zn	....	....	....	....	....	Trace.	....
	99.74	99.88	99.99	99.58	99.64	100.28	99.81

BRITISH COLUMBIA.

Peridotite, junction of Eagle Creek and Tulameen River, Yale district. *Dunose.* Described by J. F. Kemp in Bull. 193. About two-thirds olivine and one-third serpentine, with some magnetite, calcite, and magnesite as accessories. Analysis by W. F. Hillebrand, record No. 1930. P. R. C. 1472.

SiO_2	38.40	H_2O+	4.11
Al_2O_3	.29	CO_2	1.10
Fe_2O_3	3.42	P_2O_5	Trace.
FeO	6.69	S	.06
MgO	45.23	Cr_2O_3	.07
CaO	.35	NiO	.10
Na_2O K_2O	.08	MnO	.24
H_2O-	.24		100.38

TiO_2, ZrO_2, BaO, SrO, and Li_2O were absent.

HAWAIIAN ISLANDS.

Rocks A to N collected by Whitman Cross, and described by him in P. P. 88.

Analyses A to F by W. F. Hillebrand, record Nos. 2038, 2112. Rocks A and B are described by Cross in Jour. Geology, vol. 12, p. 510.

A. Soda trachyte from Puu Anahulu, North Kona, Hawaii. *Umptekose.* **Consists chiefly of alkali feldspar, with small amounts of diopside and obscure sodic amphiboles or pyroxenes. Analysis incomplete.** P. R. C. 1858.

B. Soda trachyte obsidian from Puuwaawaa, North Kona, Hawaii. ***Nordmarkose-umptekose.*** **Black glass, containing alkali feldspar microlites and ferritic particles. P. R. C. 1857.**

C. Essexitic andesite, White Hill, crater of Haleakala, Maui. ***Akerose-essexose.*** **Contains oligoclase-andesine, orthoclase, a little nephelite, augite, olivine, magnetite, and apatite. P. R. C. 1860.**

D. Plagioclase basalt, East Branch of Makaweli Canyon, Kauai. ***Camptonose-auvergnose.*** **Consists essentially of augite, olivine, plagioclase, and magnetite, with a little glassy base. P. R. C. 1864.**

E. Melilite-nephelite basalt, Kilauea Landing, north coast of Kauai. *Uvaldose.* Consists essentially of augite, olivine, melilite, nephelite, magnetite, and apatite, with a little analcite. In vesicles, also, an undetermined fibrous zeolite. P. R. C. 1867.

F. Portion of E soluble in 1:40 nitric acid.

	A	B	C	D	E	F
SiO_2	62.11	62.19	49.55	45.48	37.50	15.84
Al_2O_3	22.97	17.43	17.78	11.87	9.12	7.68
Fe_2O_3		1.65	4.65	1.98	5.59	1.47
FeO		2.64	5.89	9.87	8.81	.47
MgO	......	.40	2.49	13.28	13.72	3.39
CaO	.85	.86	7.01	10.97	13.85	5.21
Na_2O	6.89	8.28	6.12	2.21	2.69	2.28
K_2O	4.82	5.03	2.29	.77	.63	.60
H_2O-	[a] 1.60	.14	.29	.23	1.05	[b] 1.05
H_2O+		.39	.34	.74	2.35	[b] 2.35
TiO_2	......	.37	2.09	1.90	3.21	.05
ZrO_2	......	.04	.01	None.	.02	......
CO_2	......	.02	None.	None.	.27	.27
P_2O_5	......	.14	1.10	.25	.90	.90
Cl	......	Undet.	(?)	(?)	.05	.03
S	......	None.	......	......	Trace.	......
Cr_2O_3	......	Trace.	None.	.08	.07	(?)
NiO (CoO)	......	None.	None.	.04	.04	(?)
MnO	......	.32	.28	.16	.15	in Al_2O_3
BaO	......	.03	.05	.04	.07	(?)
SrO	......	None.	.08	Trace?	.05	in CaO
Li_2O	......	Trace.	None.	None.	Trace.	(?)
V_2O_3	......	None.	.015	.04	.05	(?)
FeS_2	......	......	.03	.03	......	(?)
	99.24	99.93	100.065	99.94	100.19	41.59

[a] Loss on ignition. [b] Assumed.

G. Soda trachyte, Launiopoko Hill, near Lahaina, Maui. *Nordmarkose.* Consists mainly of albite-oligoclase microlites, with some interstitial orthoclase, acmite, ægirite, and iron oxide. P. R. C. 1869.

H. Essexitic andesite, ravine west of Viera's ranch house, crater of Haleakala, Maui. *Akerose.* Contains andesine, oligoclase, alkali feldspar, nephelite, augite, olivine, magnetite, and apatite. P. R. C. 1859.

I. Picritic basalt, Sand Hills, Nanawale, Puna, Hawaii. *Rossweinose-wehrlose.* Composed of olivine, augite, labradorite, magnetite, and a ferritic base. P. R. C. 1865.

J. Picritic basalt, west rim of crater of Haleakala, Maui. *Rossweinose-uvaldose.* Composed of augite, olivine, labradorite, a little nephelite, magnetite, and ferritic glass. P. R. C. 1866.

Analyses G to J by G. Steiger, record Nos. 2526, 2542, 2766.

	G	H	I	J
SiO_2	61.69	51.26	47.25	42.99
Al_2O_3	17.33	16.74	9.07	10.21
Fe_2O_3	5.30	2.92	1.45	3.01
FeO	.07	7.11	10.41	10.28
MgO	.16	2.80	19.96	14.61
CaO	1.05	6.61	7.88	12.54
Na_2O	7.47	5.86	1.38	1.40
K_2O	3.47	2.25	.35	.52
H_2O-	.42	.26	.08	.82
H_2O+	1.93	.42	.04	1.10
TiO_2	.67	2.57	1.61	2.52
ZrO_2	.16	None.	None.	None.
CO_2	None.	Trace.	None.	None.
P_2O_5	.05	.81	.21	.29
S	.02	....	....	....
Cr_2O_3	....	None.	.12	.06
NiO	....	None.	.09	.06
MnO	.21	.23	.13	.17
BaO	.07	.10	None.	None.
SrO	.03	.09	None.	None.
	100.10	100.03	100.03	100.58

K. Plagioclase basalt, fragment in tuff, rim of caldera of Kilauea, Hawaii. *Auvergnose.* Composed of labradorite, augite, olivine, and magnetite. P. R. C. 1862. Analysis by Steiger, record No. 2471.

L. Plagioclase basalt, East Branch of Makaweli Canyon, Kauai. *Auvergnose.* Contains labradorite, olivine, augite, magnetite, and apatite. P. R. C. 1863. Analysis by W. T. Schaller, record No. 2472.

M. Sodic gabbro, Kauaiite, bowlder in bed of Waiale Canyon, near Waimea Canyon, Kauai. *Kilauose.* Contains labradorite, alkali feldspars, nephelite (?), augite, olivine, ilmenite, and apatite. P. R. C. 1861. Analysis by Schaller, No. 2472.

N. Nephelite melilite basalt, quarry near Moiliili church, near Honolulu, Oahu. *Uvaldose-casselose.* Contains nephelite, melilite, augite, olivine, magnetite, and apatite. P. R. C. 1868. Analysis by Steiger, No. 2471.

	K	L	M	N
SiO_2	50.03	48.99	45.81	36.34
Al_2O_3	12.10	13.73	11.90	10.14
Fe_2O_3	2.10	1.60	4.62	6.53
FeO	9.97	10.46	8.09	10.66
MgO	9.57	13.53	5.39	10.68
CaO	10.58	7.34	10.67	13.10
Na_2O	2.01	1.62	4.28	4.54
K_2O	.44	.27	1.40	1.78
H_2O-	.16	.10	.47	1.00
H_2O+	.32	.27	.53	1.00
TiO_2	2.57	1.73	4.05	2.89
ZrO_2	....	None.	None.	....
CO_2	....	.24	None.	.15
P_2O_5	.21	.13	2.20	1.02
S	....	.04	.03	.04
Cr_2O_3	....	.02	None.	....
V_2O_3	....	.06	....	....
NiO	....	.05	....	....
MnO	.16	.20	.17	.20
BaO	....	Trace?	.04	....
SrO	....	None.	Trace.	....
	100.22	100.38	99.65	100.07

The following rocks from the Island of Hawaii are described by R. A. Daly in Jour. Geology, vol. 19, p. 289. Analyses by G. Steiger, record No. 2500.

A. Porphyritic gabbro, from near Uwekahuna station, Kilauea. *Wehrlose.*[1] Contains olivine, augite, labradorite, magnetite, ilmenite, and apatite. P. R. C. 1847.

B. Olivine basalt, flow of 1852, Mauna Loa. *Hilose.*[2] Contains olivine, augite, labradorite, ilmenite, magnetite, and apatite. P. C. R. 1848.

---

[1] Called by Cross *rossweinose-wehrlose.*

[2] Called by Cross *palisadose-hilose.*

C. Olivine separated from B.

D. Trachydolerite, Mauna Kea. *Andose.* Contains plagioclase, alkali feldspar, augite, magnetite, apatite, and ilmenite. P. R. C. 1849.

E. Andesitic basalt, Mauna Kea. *Andose.* Contains plagioclase, augite, olivine, magnetite, ilmenite, and apatite. P. R. C. 1850.

	A	B	C	D	E
SiO_2	46.59	48.57	40.42	50.92	49.73
Al_2O_3	7.69	10.51	.32	17.59	16.39
Fe_2O_3	2.20	2.19	.15	3.80	7.58
FeO	10.46	9.45	11.44	6.69	3.98
MgO	21.79	17.53	47.08	3.90	4.06
CaO	7.41	8.06	.23	6.97	7.17
Na_2O	1.33	1.59	....	4.28	4.12
K_2O	.28	.34	....	1.86	1.93
H_2O-	.04	.10	....	.35	.81
H_2O+	.37	.37	....	.79	.54
TiO_2	1.83	1.48	.08	2.55	3.05
ZrO_2	None.	....	....	....	.03
P_2O_5	.11	.19	....	.40	.84
Cr_2O_3	.13	.10	.18	None.	None.
NiO	.12	.08	.34	None.	.04
MnO	.18	.16	.10	.20	.23
BaO	None.	....	....	....	.03
	100.53	100.72	100.34	100.30	100.53

CO_2, S, and SrO absent.

PANAMA AND THE CANAL ZONE.

Rocks collected by D. F. MacDonald, but no petrographic descriptions furnished. The "mud rocks" are included here as immediate derivatives of the lavas.

A. Rhyolite, Ancon Hill, Canal Zone. *Lassenose.* Analysis by G. Steiger, record No. 2598. P. R. C. 1946.

B. Gray andesitic breccia, Contractors Hill, Canal Zone. *Yellowstonose.* Analysis by R. C. Wells, No. 2593. P. R. C. 1941.

C. "Contractors Hill rock," Canal Zone. Analysis by Wells, No. 2593. P. R. C. 1943.

D. Andesitic rock, near Empire, Canal Zone. *Hessose.* Analysis by Chase Palmer, No. 2604. P. R. C. 1952.

E. Black, glassy lava, Canal Zone. Analysis by Wells, No. 2593. P. R. C. 1944.

F. Lava, near Las Cascadas, Canal Zone. *Dacose.* Analysis by Steiger. No. 2598. P. R. C. 1947.

G. Lava, Gold Hill, Canal Zone. *Hessose.* Analysis by Steiger, No. 2598. P. R. C. 1948.

	A	B	C	D	E	F	G
SiO_2	69.20	65.17	46.63	48.94	62.23	60.03	51.04
Al_2O_3	15.00	15.22	14.94	18.77	14.95	16.15	17.34
Fe_2O_3	1.57	2.08	6.40	4.89	2.04	5.25	2.88
FeO	1.83	3.98	3.15	4.77	1.52	2.67	7.33
MgO	.69	1.19	6.15	1.59	.75	.60	5.50
CaO	1.88	3.79	7.31	11.50	3.10	3.91	9.79
Na_2O	5.87	3.71	1.49	2.13	5.08	4.26	2.88
K_2O	1.81	1.52	2.18	1.14	1.26	3.45	.53
H_2O-	.90	2.57	10.44	2.32	8.94	.84	.96
H_2O+	.67			1.46		.96	.72
TiO_2	.52	.96	1.14	1.34	.59	1.36	1.32
CO_2	None.	.32	.55	None.	Trace.	None.	None.
P_2O_5	.10	....	Trace.	.28	.04	.41	.25
MnO	.15	.06	.20	.83	....	.15	.13
	100.19	100.57	100.58	99.96	100.50	100.04	100.67

H. Green mud rock, Gold Hill, Canal Zone. Analysis by Wells, No. 2593. P. R. C. 1942.

I. Red mud rock, Gold Hill. Analysis by W. T. Schaller, No. 2597. P. R. C. 1949.

J. Green mud rock, about 1,000 feet north of Contractors Hill, Canal Zone. Analysis by Wells, No. 2593. P. R. C. 1945.

K. Reddish mud lava breccia, near Contractors Hill. Analysis by Schaller, No. 2597. P. R. C. 1950.

L. Mud lava breccia, Canal Zone. Analysis by Schaller, No. 2597. P. R. C. 1951.

M. "Gatun formation," Canal Zone. Analysis by Chase Palmer, No. 2604. P. R. C. 1953.

	H	I	J	K	L	M
SiO_2	52.41	48.36	61.22	48.83	51.37	42.43
Al_2O_3	18.18	18.98	13.08	13.63	15.40	16.26
Fe_2O_3	5.20	10.53	4.58	5.49	4.33	6.26
FeO	3.67	1.59	.90	3.71	2.13	2.31
MgO	1.59	.04	.85	3.32	3.95	3.35
CaO	1.62	1.84	1.99	4.36	4.15	9.30
Na_2O	.94	.61	.50	1.08	1.56	1.53
K_2O	.81	.34	.34	.10	.95	1.58
H_2O-	15.04	9.47	15.15	12.26	10.33	7.95
H_2O+		6.71		5.41	4.27	6.08
TiO_2	.87	.88	.85	.95	.88	.73
CO_2	.11	None.	.20	.34	None.	1.65
P_2O_5	Trace.	.22	None.	.22	.38	.25
MnO	.20	....	Trace.	....	....	.06
	100.64	99.57	99.66	99.70	99.70	99.83

N. Andesite, Point Farfan. *II. 4. 2. 5.* Sp. gr. 2.57. P. R. C. 1887.

O. Granodiorite, Cocovi Islands. *Amadorose.* Sp. gr. 2.52. Analyses N, O, by R. C. Wells, record No. 2799. P. R. C. 1892.

P. Diorite, Point Farfan. *Beerbachose.* P. R. C. 1888.

Q. Basalt, Monte Lirio. *Camptonose.* Analyses P, Q, by W. C. Wheeler, No. 2800. P. R. C. 1889.

	N	O	P	Q
SiO_2	57.39	63.51	51.72	48.23
Al_2O_3	15.84	18.07	15.38	14.69
Fe_2O_3	2.38	2.01	3.35	4.49
FeO	5.96	2.18	7.91	5.85
MgO	2.41	2.19	4.38	6.73
CaO	5.24	5.14	7.84	12.12
Na_2O	5.23	4.08	4.37	2.55
K_2O	.84	.88	.47	1.49
H_2O-	1.09	1.07	.56	1.50
H_2O+	1.74	.60	2.00	.98
TiO_2	1.35	.33	1.67	1.00
ZrO_2	Trace.	None.	....	....
CO_2	Trace.	None.	None.	Trace.
P_2O_5	.68	.19	.49	.46
SO_3	....	....	.63	.05
Cl	.05	.01	.12	.09
F	Trace.	None.	None.	None.
S	.01	.01	....	....
V_2O_3	Trace.	Trace.	....	....
Cr_2O_3	....	....	None.	.06
MnO	.18	.06	.16	.17
BaO	.02	.03	....	....
	100.41	100.36	100.45	100.46

Analyses R to V, by W. C. Wheeler, record No. 2838.

R. Andesitic rock, Chorcha Mountain, Chiriqui. *Andose.* P. R. C. 1932.

S. Dioritic rock, Boquete. *Tonalose.* P. R. C. 1933.

T. Recrystallized, bedded, volcanic ash, Chiriqui Mountain. P. R. C. 1934.

U. Dioritic rock, Boquete. *Tonalose.* P. R. C. 1935.

V. Basaltic rock, 8 miles southwest of Bejuca. P. R. C. 1936.

	R	S	T	U	V
SiO_2	50.83	59.13	60.20	59.61	64.16
Al_2O_3	18.90	16.97	18.89	16.68	14.42
Fe_2O_3	2.95	2.18	2.15	2.66	2.72
FeO	6.86	4.31	1.97	3.56	2.65
MgO	3.06	2.38	2.49	2.10	1.35
CaO	7.92	7.69	6.22	5.58	3.24
Na_2O	3.20	3.36	4.88	3.51	4.42
K_2O	2.44	2.57	2.05	2.95	2.42
H_2O-	1.06	.23	.18	.50	.47
H_2O+	.70	.76	.54	1.31	1.49
TiO_2	1.08	.68	.38	.73	.94
CO_2	....	Trace.	....	.14	1.58
P_2O_5	.66	.19	.17	.18	.23
MnO	.19	.12	.08	.14	.11
	99.85	100.57	100.20	99.65	100.20

GUATEMALA.

Volcanic dust from the volcano Santa Maria, collected on deck of steamer *Luxor*, 60 miles distant in San Benito Harbor, October 25, 1902. *Yellowstonose.* Analysis by E. T. Allen, record No. 2011.

SiO_2	59.38	H_2O-	.36
Al_2O_3	19.86	H_2O+	.73
Fe_2O_3	3.84	TiO_2	.49
FeO	2.17	P_2O_5	.18
MgO	1.18	SO_3	.27
CaO	5.80		
Na_2O	4.92		100.33
K_2O	1.15		

Traces of Cr_2O_3, MnO, and BaO are present. CO_2 is absent.

WEST INDIES.

Volcanic ejectamenta from Mont Pelée, Martinique, and La Soufrière, St. Vincent, eruptions of May, 1902. See Diller, Nat. Geog. Mag., vol. 13, p. 285. Also Diller and Steiger, Science, vol. 15, p. 947.

A. Pumice, Mont Pelée, eruption of May 8. *Bandose-tonalose.* Hypersthene andesite, containing plagioclase, hypersthene, and magnetite in a vesicular, glassy groundmass.

B. Sand, same eruption as A, collected on deck of the steamer *Roddam* after its arrival at Santa Lucia. *Tonalose-bandose.*

C. Dust, Mont Pelée, eruption of May 20. *Tonalose.* Collected on deck of steamer *Potomac* in harbor at Fort de France. B and C resemble A mineralogically.

D. Volcanic dust from about 1 mile north of Georgetown, St. Vincent. *Bandose.* Collected by E. O. Hovey and not described in the articles cited above.

E. Pumice from La Soufrière. *Bandose.* Collected by R. T. Hill. Hypersthene andesite containing plagioclase, hypersthene, augite, olivine, and magnetite. (Diller.)

F. Dust from La Soufrière. *Bandose-placerose.* Collected on steamer *Coya*, at sea, about 275 miles southeast of St. Vincent, May 7, 1902. Contains feldspars, pyroxenes, magnetite, and possibly other minerals. Contained 0.57 per cent of soluble salts.

Analyses A to D by W. F. Hillebrand, record No. 1991. E and F by George Steiger, record Nos. 1984, 1989.

	A	B	C	D	E	F[a]
SiO_2	61.07	60.01	63.23	55.08	55.64	57.62
Al_2O_3	17.55	17.54	16.73	18.00	18.21	19.76
Fe_2O_3	2.13	2.88	2.58	2.46	3.63	3.43
FeO	4.13	4.30	3.12	4.57	4.83	3.90
MgO	2.26	2.76	1.84	3.34	3.48	1.82
CaO	6.28	6.80	6.01	7.79	8.14	6.45
Na_2O	3.50	3.41	3.71	3.48	3.55	3.87
K_2O	.98	.89	1.11	.65	.58	.71
H_2O-	.23	.10	.17	.66	.20	.41
H_2O+	1.37	.30	.48	1.39	.54	.59
TiO_2	.47	.45	.40	.80	.98	.87
ZrO_2	Trace?	Trace?	Trace?	(?)	....	....
P_2O_5	.15	.15	.15	.17	.11	.17
SO_3	....	....	....	.24	None.	.29
S	.016	Trace.	Trace.	....	.04	.11
Fe_7S_8	....	....	....	.91	....	....
MnO	.21	.23	.18	.21	.19	.08
BaO	.02	.03	.03	Trace.	.03	....
Li_2O	Trace.	Trace.	Trace.	Trace.	....	....
	100.366	99.85	99.74	99.75	100.15	100.08

[a] Soluble in water; CaO, 0.20; Na_2O, 0.08; SO_3, 0.29; and a trace of Cl.

CO_2, Cl, NiO, SrO absent, except a trace of Cl in analysis F.

BRAZIL.

A kyanitic schist from Serra do Gigante, near Diamantina, was analyzed at the request of Prof. O. A. Derby, who describes the rock in Am. Jour. Sci., 4th ser., vol. 7, p. 343. Analysis by Hillebrand, record No. 1783. Contains kyanite, chlorite, sericite, quartz, and rutile.

A. Bulk analysis of the schist.

B. Portion soluble in hydrochloric acid.

C. Portion soluble in strong sulphuric acid.

D. Residue insoluble in sulphuric acid.

The bracketed figures are deduced from other columns than the one in which they appear.

	A	B	C	D
SiO_2	38.32	10.78	14.76	[23.56]
Al_2O_3	28.16	10.42	14.77	[13.39]
Fe_2O_3	2.24	[1.78]	[2.24]	None.
FeO	4.02	[3.21]	[4.02]	None.
MgO	12.04	9.34	[12.04]	None.
CaO	.32	.34	.32	....
Na_2O	.16	[.03]	[.03]	.13
K_2O	1.11	.26	[.26]	.85
H_2O-	.55	[.55]	[.55]	....
H_2O+	7.46	5.36	6.80	.66
TiO_2	4.93	.10	.20	[4.73]
P_2O_5	.47	.47	.47	....
ZrO_2	.09	Trace.	(?)	[.09]
CoO, NiO	.04	(?)	[.04]	....
MnO	.16	(?)	[.16]	....
SrO	Trace.	(?)	(?)	....
Li_2O	Trace.	Trace.	Trace.	Trace.
S	Trace.	....	....	....
F	Trace?	....	....	....
	100.07	42.64	56.66	43.41

TASMANIA.

Two analyses of so-called "volcanic bombs" or "buttons" were made by W. F Hillebrand, record No. 2097, at the request of W. H. Twelvetrees, of Launceston, Tasmania. These curious forms of volcanic glass have every appearance of artificiality, but are said to be found under such conditions and in so many localities that the idea of their human origin is precluded. A paper on the subject by R. H. Walcott may be found in Proc. Royal Soc. Victoria, vol. 11, p. 23, 1898.

A. From Upper Weld tindrift. *Almerose.* Analysis incomplete because of insufficient material. Sp. gr., 2.454 at 18.5°.

B. From Pieman. *I. 3. 4. 3.* Sp. gr., 2.428 at 22°.

	A	B
SiO_2	69.80	73.59
Al_2O_3	15.02	12.35
Fe_2O_3	.40	.38
FeO	4.65	3.79
MgO	2.47	1.80
CaO	3.20	3.76
Na_2O	1.29	1.03
K_2O	2.56	1.93
H_2O-	Undet.	.27
H_2O+	Undet.	.53
TiO_2	.80	.70
ZrO_2	(?)	.01
MnO	.18	.15
NiO	(?)	None.
CuO	(?)	Trace?
SrO	None.	Trace.
BaO	None.	Trace.
Li_2O	Trace.	Trace.
	100.37	100.29

ANALYSES OF SANDSTONES, CHERTS, AND SINTERS.

SANDSTONES.

EASTERN STATES.

A. Calciferous sandstone, New Sweden, Me. Described by H. E. Gregory in Bull. 165. Analysis by W. F. Hillebrand, record No. 1795. Contains quartz, calcite, feldspar, magnetite, muscovite, and siderite.

B. Brown sandstone, Hummelstown, Pa. Analysis by E. A. Schneider, record No. 1280. Described by Diller in Bull. 150, p. 77. P. R. C. 14.

C. Triassic sandstone from the Jaittelle quarry, near Hancock, Md. Hard, compact, brown. Analysis by F. W. Clarke, record No. 613.

	A	B	C
SiO_2	54.23	88.13	76.43
Al_2O_3	7.38	5.81	17.78
Fe_2O_3	.54	1.77	
FeO	1.37	.31	....
MgO	3.29	.53	.92
CaO	14.56	.20	.84
Na_2O	1.65	.06	Undet.
K_2O	1.74	2.63	Undet.
H_2O-	.25	.23	2.79
H_2O+	1.22	.26	
TiO_2	.28	....	....
P_2O_5	.07	....	....
CO_2	13.48	....	....
MnO	Undet.	....	Trace.
	100.06	99.93	98.76
Insoluble in HCl	....	....	88.68

MICHIGAN, WISCONSIN, AND IOWA.

A. Yellow sandstone, Stony Point, Mich. Analysis by F. W. Clarke, record No. 213.

B. Potsdam sandstone, Ablemans, Sauk County, Wis. Described by Diller in Bull. 150, p. 80. Analysis by E. A. Schneider, record No. 1280. P. R. C. 15.

C. From Boscobel, Wis.

D. From Beetown, Wis. Analyses C, D, by G. Steiger, record No. 2227.

E. From Springdale station, Sioux City, Iowa. Analysis by Steiger, No. 2295.

Rocks C, D, E are St. Peter sandstone, described as "glass sands" by E. F. Burchard in Bull. 285, p. 459, and Bull. 315, p. 377. Partial analyses only.

	A	B	C	D	E
SiO_2	84.57	99.42	99.47	99.17	96.90
Al_2O_3	5.90	.31	....	.25	1.22
Fe_2O_3	6.48		.07	.22	.28
MgO	.68	....	....	....	.05
CaO	....	....	....	....	.14
Ignition	1.92	.18	....	....	1.07
	99.55	99.91	99.54	99.64	99.66
Insoluble in HCl	91.87	....	....	....	....

OHIO.

A. Blue sandstone from near Cleveland. Analysis by T. M. Chatard, record No. 214.

B. Sandstone from Berea. Analysis by L. G. Eakins, record No. 914.

C, D, E. Three samples of the "Peebles-Henley sandstone," from Portsmouth. Analyses by H. N. Stokes, record No. 1239. Alkalies, etc., undetermined.

	A	B	C	D	E
SiO_2	91.67	92.91	90.40	89.32	87.12
Al_2O_3	6.92	3.78	5.15	5.52	5.96
Fe_2O_3	Trace.	Trace.	.65	.87	.85
FeO	......	.91	.27	.35	.85
MgO	.34	Trace.	.28	.51	.73
CaO	.28	.31	......	......	......
Na_2O	......	.34	......	......	......
K_2O	......	.61	......	......	......
H_2O	1.17	1.19	.99	1.49	2.00
	100.38	100.05	97.74	98.06	97.51
Insoluble in HCl	97.50	......	98.00	96.90	95.52

KENTUCKY, MISSISSIPPI, MISSOURI, AND ARKANSAS.

A. Carboniferous sandstone adjoining the peridotite dike of Elliott County, Ky See Diller, Am. Jour. Sci., 3d ser., vol. 32, p. 125. Analysis by T. M. Chatard, record No. 354.

B. Fine-grained, fissile sandstone. Same locality and reference as A.

C. "Glass sand," near Iuka, Miss. Received from E. C. Eckel. Analysis by G. Steiger, record No. 2268.

D. From Jackson, Mo.

E. From Versailles, Mo.

F. From Everton, Ark.

Rocks D, E, F are St. Peter sandstones, described by Burchard in Bull. 285, p. 459, and Bull. 315, p. 377. Analyses by Steiger, Nos. 2227, 2295.

	A	B	C	D	E	F
SiO_2	60.78	60.25	97.74	99.52	99.03	99.55
Al_2O_3	10.54	20.18	.80	.16	.40	.13
Fe_2O_3	3.27	1.53		.07	.13	.09
FeO	......	3.42	......	......		......
MgO	1.59	3.52	None.	......	.11	......
CaO	10.15	.51	None.	......	.29	......
Na_2O	1.41	.39	.22	......	......	......
K_2O	2.36	3.17		......	......	......
H_2O—	.85	1.94	......	......	......	......
H_2O, ignition	2.32	5.17	1.04	......	.44	......
TiO_2	.03	.23	......	......	......	......
P_2O_5	.09	.10	......	......	......	......
CO_2	6.29	......	......	......	......	......
MnO	.10	.10	......	......	......	......
	99.78	100.51	99.80	99.75	100.40	99.77

KANSAS.

St. Peter sandstones described as "glass sands" by E. F. Burchard in Bull. 285, p. 459, and Bull. 315, p. 377. Analyses by G. Steiger, record Nos. 2222, 2227, 2295. Partial only.

A, B, C, D. From Fredonia.

E. From Neodesha.

F. From Havana.

G. From Caney.
H, I. From Niotaze.
J, K, L. From SE. ¼ sec. 13, T. 28 S., R. 12 E.
M. From near Fall River station.

	A	B	C	D	E	F	G
SiO_2	97.59	98.00	97.50	97.94	98.71	97.80	97.08
Al_2O_3			1.62				
Fe_2O_3[a]	.33	.37	.43	.63	.19	.84	.72
MgO			None.				
CaO			.10				
Ignition							
	97.92	98.37	99.65	98.57	98.90	98.64	97.80

	H	I	J	K	L	M
SiO_2	96.45	96.90	98.24	97.81	98.02	97.28
Al_2O_3	2.76	2.03	.57	.73	.81	.96
Fe_2O_3[a]	.37	.67	.35	.35	.26	.80
MgO			.04	.05	.06	.04
CaO			.06	.18	.08	.13
Ignition			.72	.80	.81	.73
	99.58	99.60	99.98	99.92	100.04	99.94

[a] Total Fe.

COLORADO, UTAH, AND ARIZONA.

A. Yellow sandstone, Armejo quarry, Colorado. Analysis, partial, by T. M. Chatard, record No. 289.

B. Sandstone, Robinson mine, Summit County, Colo. Analysis by L. G. Eakins, made in the Denver laboratory, partial.

C. Sandstone from the Logan mine, Rico district, Colorado. Consists mainly of quartz and sericite.

D. Altered sandstone, in contact with C. Same constituents, plus limonite, anglesite, and a hydrous magnesian mineral. Analyses C, D, by W. F. Hillebrand, record No. 1914. Described by Ransome, 22d Ann., pt. 2, p. 287.

E. Banded sandstone, Peoa, Utah. Described by Diller in Bull. 150, p. 80. Analysis by Schneider, record No. 1280. P. R. C. 16.

F. Brown sandstone, Flagstaff, Ariz. Analysis by T. M. Chatard, record No. 1144.

	A	B	C	D	E	F
SiO_2	81.27	56.33	83.95	62.88	96.60	[a] 79.19
Al_2O_3	9.81	.77	8.92	21.38	2.02	1.30
Fe_2O_3	1.44	.97	.48	1.09		2.45
FeO			.13			
MgO	.42	7.30	.97	2.00	.08	.23
CaO	.44	14.01	.12	.40	.04	7.76
Na_2O	Undet.	Undet.	.06	.07		
K_2O	Undet.	Undet.	3.09	6.59		
H_2O-	1.19	Undet.	[b] 1.90	5.49	.11	.32
H_2O+		Undet.			.29	2.94
CO_2		[c] 19.04	None.			5.77
SO_3				.53		
CuO			Trace.			
PbO			Trace.	.34		
MnO				Trace.		
Ag			.04	None.		
	94.57	98.42	99.66	100.77	99.14	99.96

[a] Silica and insoluble matter. [b] Loss on ignition. [c] Calculated to satisfy bases.

CALIFORNIA.

1. MOUNT DIABLO.

Described by Turner and Melville in Bull. Geol. Soc. America, vol. 2, pp. 383–414. Analyses made by W. H. Melville in the San Francisco laboratory.

A. Upper Cretaceous, Chico sandstone. Light brown, finely granular, carrying grains of mica and feldspar.

B. Lower Cretaceous, Neocomian sandstone. Hard, granular, greenish. From headwaters of Bagley Creek.

C. Miocene sandstone. Granular, particles light brown and black, friable. From near Wall Point.

D. Chico sandstone. Greenish gray, compact, crystalline.

	A	B	C	D
SiO_2	73.71	56.84	44.54	36.93
Al_2O_3	10.40	11.37	12.63	7.22
Fe_2O_3	3.89	1.46	2.50	1.59
FeO	1.88	4.95	3.08	2.95
MgO	1.62	3.10	5.55	2.34
CaO	.96	7.62	14.65	29.34
Na_2O	3.48	3.26	3.35	2.94
K_2O	.99	.86	1.37	.64
H_2O-	1.06	1.45	1.43	.57
H_2O+	2.60	3.34	2.25	3.45
P_2O_5	None.	.10	.29	.16
MnO	.17	.22	.44	.57
CO_2	None.	5.10	7.76	[a] 11.30
	100.76	99.67	99.84	100.00

[a] CO_2 determined by difference.

Traces of organic matter are found in all four sandstones, but were not determined.

2. SHASTA COUNTY.

Described by J. S. Diller in Bull. Geol. Soc. America, vol. 1, p. 411. The rock is made up of quartz, feldspar, and biotite, with a calcite cement. Serpentine, sphene, magnetite, and zircon also occur in it, but are less common.

A. From Salt Creek, one-half mile above McNett's.

B. One and one-fourth miles below Ono Bridge, north fork of Cottonwood.

C, D. Three-fourths of a mile below John Allen's, Dry Creek.

E. From John Allen's, Dry Creek.

Analyses A and B by T. M. Chatard, record No. 1106; C, D, and E, by J. E. Whitfield, record Nos. 972, 973.

	A	B	C	D	E
SiO_2	48.13	48.10	59.10	61.60	54.55
Al_2O_3	11.19	12.16	14.02	12.15	10.64
Fe_2O_3	1.25	1.02	3.16	2.09	1.59
FeO	1.47	2.14	1.42	3.30	1.16
MgO	2.22	1.65	1.72	2.33	1.29
CaO	16.39	15.88	9.35	6.92	14.30
Na_2O	2.29	2.46	2.21	2.16	2.60
K_2O	1.17	1.56	1.49	1.41	1.68
H_2O-	.78	.46	....	....	....
H_2O+	1.78	3.27	2.63	3.10	1.60
TiO_2	.24	.47	.70	Trace.	Trace.
P_2O_5	.14	.13	Trace.	.08	.10
MnO	.29	.26	Trace.	Trace.	1.53
BaO	.04	Undet.	....	....	....
CO_2	12.73	10.36	4.65	5.05	9.05
SO_3	....	....	Trace.	.27	.10
Cl	....	....	Trace.	Trace.	.72
	100.11	99.92	100.45	100.46	100.31

The following bedded sandstones of the same region are also described:

F. From Middle Fork of Cottonwood, 1 mile above Miller's.

G. Top of cascade, 1½ miles up Byron Creek from North Fork of Cottonwood.

H. Two and one-half miles above John Allen's, Dry Creek.

Analyses F and G by Chatard, record No. 1106; H by Whitfield, record No. 974.

	F	G	H
SiO_2	55.85	67.62	60.74
Al_2O_3	13.20	13.63	10.25
Fe_2O_3	2.56	1.25	4.31
FeO	4.77	3.27	6.21
MgO	1.90	2.34	3.69
CaO	6.93	2.80	4.97
Na_2O	2.60	2.78	1.83
K_2O	1.89	1.11	.52
H_2O-	1.13	.64	....
H_2O+	2.99	2.83	4.36
TiO_2	.76	.48	.86
P_2O_5	.18	.08	Trace.
MnO	.24	.15	Trace.
BaO	Undet.	.03	....
CO_2	4.97	.72	2.29
SO_3	....	....	.40
Cl	....	....	Trace.
	99.97	99.73	100.43

3. SULPHUR BANK.

Described by Becker in Mon. XIII, p. 92. Analysis made by Melville in the San Francisco laboratory. An altered sandstone, showing grains of quartz, plagioclase, and orthoclase.

SiO_2	68.50	K_2O	1.26
Al_2O_3	12.82	H_2O-	.28
Fe_2O_3	1.29	H_2O+	2.11
FeO	3.37	TiO_2	.60
MgO	2.21	P_2O_5	.16
CaO	1.82	MnO	.02
Na_2O	6.03		
			100.47

CHERT.

From the lead-zinc region of southwestern Missouri and its extension into Kansas. Collected by W. P. Jenney.

A. Unaltered chert, East Hollow, Belleville, Jasper County, Mo.

B. Partly altered, same locality.

C. Altered to "cotton rock," same locality.

D. From the Surprise mine, Joplin, Mo.

E. Blue chert, unaltered, Bonanza shaft, Galena, Kans.

F. Same locality.

G. Altered, same locality.

H. Jasperite, Joplin, Mo.

I. Jasperite, Galena, Kans.

Analyses A to G by E. A. Schneider, record No. 1205; H and I by L. G. Eakins, record No. 1208.

	A	B	C	D	E	F	G	H	I
SiO_2	98.17	98.92	98.71	99.46	99.23	98.60	99.13	95.77	97.33
Al_2O_3, Fe_2O_3	.83	.48	.43	.29	.22	.52	.16	1.84	1.89
MgO	.01	.02	.02	Trace.	Trace.	Trace.	.01	.24	.09
CaO	.05	.03	.03	.04	.02	.10	Trace.	.54	.11
Ignition	.78	.42	.50	.34	.50	.40	.20	1.17	.77
	99.84	99.87	99.69	100.13	99.97	99.62	99.50	99.56	100.19

SILICEOUS SINTERS.

From the Yellowstone National Park and similar localities. Analyses A to E by J. E. Whitfield, record Nos. 97, 100, 707, 708, and 861. Discussed by Weed in 9th Ann., p. 619.

A. Dried siliceous jelly from Emerald Spring, Upper Basin.
B. Sinter from Solitary Spring, Upper Basin.
C. Grayish sinter from margin of Splendid Geyser.
D. Compact sinter from Old Faithful Geyser.
E. From Asta Spring, Hillside Group. Sp. gr., 1.7122.

	A	B	C	D	E
SiO_2	93.37	93.88	81.95	89.54	89.72
Al_2O_3	1.16	1.73	6.49	2.12	1.02
Fe_2O_3	Trace.	.14	Trace.	Trace.	
MgO	.05	.07	.15	Trace.	Trace.
CaO	.29	.25	.56	1.71	2.01
Na_2O	.11	.28	2.56	1.12	....
K_2O	.02	.23	.65	.30	....
H_2O, ignition	4.17	3.37	7.50	5.13	7.34
NaCl	.08	.18	Trace.	Trace.	....
SO_3	.31	.20	.16	Trace.	Trace.
C, organic	.78	....	....	....	....
H, organic	.07	....	....	....	....
	100.41	100.33	100.02	99.92	100.09

Analyses F to O, are all of Yellowstone Park deposits. Record Nos. 236, 703, 697, 706, 698, 709, 812, 866, and 1012. Analysis N by T. M. Chatard; all the others by J. E. Whitfield. Samples collected by W. H. Weed.

F. Geyserite incrustation, Spring No. 8, Giant Group, Upper Basin.
G. Incrustation from margin of crater, Surprise Geyser.
H. Deposits from Coral Spring, Norris Basin.
I. Sediment, Vixen Geyser.
J. Deposit from Artemisia Geyser.
K. Opal deposit, Norris Basin.
L. Incrustation, Excelsior Geyser Basin. Bottom layer, compact, opaline.
M. Same as L, top layer, sintery.
N. Incrustation, platform near Union Geyser.
O. Black coating, the "Minute Man," Norris Basin.

	F	G	H	I	J
SiO_2	72.25	92.26	92.72	92.67	83.10
Al_2O_3	10.96	1.18	1.77	1.42	6.02
Fe_2O_3	.76	Trace.			Trace.
FeO	.31	....	....	....	....
CaO	.74	1.48	.56	.66	.80
MgO	.10	.06	Trace.	....	.21
Na_2O	3.55	....	....	....	2.18
K_2O	1.66	....	....	....	.87
H_2O	[a] 9.02	4.97	4.81	5.22	6.73
C	.20	....	....	....	....
NaCl	.36	Trace.	....	....	....
SO_3	[b] .45	None.	....	.17	.28
	100.36	99.95	99.86	100.14	100.19

---

[a] Includes H of organic matter.

[b] Whether as S or SO_3 was not determined.

	K	L	M	N	O
SiO_2	93.60	90.85	94.40	90.28	85.08
Al_2O_3	1.06	.83	.79	2.82	....
Fe_2O_3	Trace.			Trace.	2.65
CaO	.50	.46	None.	.30	1.67
MgO	Trace.	Trace.	None.	.07	Trace.
Alkalies	....	....	....	Undet.	....
H_2O-	4.71	7.90	5.02	1.86	[a] 10.67
H_2O+				3.95	
S	Trace.	....	....	....	....
	99.87	100.04	100.21	99.28	100.07

[a] Loss on ignition. Water and organic matter.

The following foreign sinters were analyzed for comparison with the Yellowstone Park specimens:

P, Q, R. Three samples of sinter from Rotorua, New Zealand. Analyses by J. E. Whitfield, record No. 998. Discussed by Weed in 9th Ann., p. 619.

S. Sinter from Mount Morgan gold mine, Queensland. Described by Weed in Am. Jour. Sci., 3d ser., vol. 42, p. 165. Analysis by E. A. Schneider, record No. 1254.

	P	Q	R	S
SiO_2	92.47	90.28	74.63	94.02
Al_2O_3	2.54	3.00	15.59	2.27
Fe_2O_3	....	....	....	
MgO	.15	Trace.	Trace.	Trace.
CaO	.79	.44	1.00	.07
Na_2O	....	....	.30	....
K_2O	....	....	1.02	....
H_2O-	....	....	....	1.07
Ignition	3.99	6.24	7.43	2.29
	99.94	99.96	99.97	99.72

ANALYSES OF CARBONATE ROCKS.

MAINE AND VERMONT.

A. Limestone, Islesboro, Maine. Collected by George Otis Smith. Analysis by W. T. Schaller, record No. 2139. Partial only; CO_2 calculated to satisfy bases.

B. White marble, Rutland, Vt. Analysis by L. G. Eakins, record No. 1213.

C. The portion of A insoluble in dilute hydrochloric acid. Same analyst and number.

D. Dolomite, Green Peak quarry, Dorset, Vt. Analysis by George Steiger, record No. 1938. Described by Dale in Bull. 195.

	A	B	C	D
Insoluble		8.00		
SiO_2	3.76		56.69	8.36
Al_2O_3	1.03	.39	31.16	1.77
Fe_2O_3	.43			.22
FeO		.14	2.13	1.08
MgO	1.16	Trace.	3.27	16.68
CaO	51.30	50.79	2.68	29.03
Na_2O			Undet.	.06
K_2O			Undet.	1.08
H_2O-		1.01		.03
H_2O+				.42
CO_2	41.59	39.80		41.66
	99.27	100.13	95.93	100.39

MASSACHUSETTS.

A. White marble, Lee. Analysis by E. A. Schneider, record No. 1279. Described by Diller in Bull. 150, p. 299. P. R. C. 116.

B. Limestone, Lee. Collected by B. K. Emerson. From cut on west side of railroad. Analysis by George Steiger, record No. 1654.

C. Dolomite, Charlemont. Collected by Emerson. Analysis by Eakins, record No. 1343.

D. Dolomite, Webster. Collected by Emerson. Analysis by H. N. Stokes, record No. 1634.

	A	B	C	D
Insoluble	.19			
SiO_2		.95	.67	1.01
Al_2O_3	.24	.09	Trace.	.17
Fe_2O_3		None.	.08	None.
FeO		.10	7.60	.37
MnO			1.61	.08
NiO			.03	
CaO	30.88	54.75	28.63	30.82
MgO	21.42	.56	16.17	21.35
K_2O		.15		.10
Na_2O		.02		.01
H_2O		.08		.09
P_2O_5		.03		.06
CO_2	46.72	43.38	45.35	45.84
SO_3		.05		
	99.45	100.16	100.14	99.90

NEW YORK.

A. Dolomite marble, New York Quarry Company, Tuckahoe, Westchester County. Analysis by W. F. Hillebrand, record No. 746.

B. Hydraulic cement rock, Akron. Analysis by George Steiger, record No. 1655. Described by Diller in Bull. 150.

	A	B
Insoluble	1.33	
SiO_2		9.03
TiO_2		.16
Al_2O_3		2.25
Fe_2O_3	.21	.85
FeO		.52
CaO	30.68	26.84
MgO	20.71	18.37
K_2O		.85
Na_2O		None.
H_2O	.16	.98
P_2O_5		.03
CO_2	46.66	40.33
Organic matter		
	99.75	100.21

PENNSYLVANIA.

A. Compact gray limestone, Greason. Described by Diller in Bull. 150. Analysis by E. A. Schneider, record No. 1279.

B. Limestone, quarry on south side of Jordan Creek, near Jordan Bridge, South Whitehall.

C. Quartzose dolomite, same locality as B.

D. Hydraulic limestone, Atlas Cement Company's quarry, Whitehall.

Analyses B, C, D, by W. F. Hillebrand, record No. 2016. Samples collected by T. N. Dale.

	A	B	C	D
Insoluble	11.07			
SiO_2		3.72	2.80	18.30
Al_2O_3		.81	.84	6.11
Fe_2O_3				1.85
FeO				
MgO	9.00	3.17	17.87	2.13
CaO	39.26	48.95	31.68	36.38
Na_2O				.35
K_2O				1.17
H_2O-	.18			.38
H_2O+				1.91
TiO_2		Undet.	Undet.	.24
CO_2	38.82	41.58	43.62	28.96
P_2O_5		Undet.	Undet.	.16
MnO			Trace.	.14
Li_2O				Trace.
FeS_2				.94
Carbonaceous matter	.75			1.11
	99.08	98.23	96.81	100.13

MARYLAND.

A. Dolomite marble, Cockeysville. Analysis by E. A. Schneider, No. 1279. P. R. C. 117.

B. An earlier sample of D. Analysis by J. E. Whitfield, record No. 827. P. R. C. 117. Described by Diller in Bull. 150.

	A	B
Insoluble	5.57	......
SiO_2	......	.44
Al_2O_3	.40	1.22
Fe_2O_3		......
FeO	......	Trace.
CaO	29.08	30.73
MgO	20.30	20.87
H_2O	......	1.22
CO_2	44.26	45.85
	99.61	100.33

VIRGINIA AND WEST VIRGINIA.

A. Limestone, upper ledge, Moundsville Narrows, W. Va.

B. Same as A, lower ledge. Analyses A and B by T. M. Chatard, record No. 127.

C. Trenton limestone, Lexington, Va. Analysis by R. B. Riggs, record No. 365.

D. Limestone, Staunton, Va. Analysis by George Steiger, record No. 1630.

E. Part of D insoluble in one-tenth hydrochloric acid.

F. Soluble part of D. Analyses E and F, also by Steiger, same number. These three analyses are accompanied by analyses of the residual clay, formed by the weathering of the limestone. See section on clays.

	A	B	C	D	E	F
Insoluble	10.33	1.53	......	......	......	......
SiO_2	......	......	.44	7.37	6.98	.39
TiO_2	......	......	......	.09	.09	None.
Al_2O_3	......	......	......	1.92	1.39	.53
Fe_2O_3	.90	.96	.42	.29	.25	.04
FeO	......	......	......	.63	None.	.63
MnO	Trace.	Trace.	......	None.	None.	None.
CaO	48.02	53.26	54.77	28.39	.04	28.35
MgO	1.08	.93	Trace.	18.30	.15	18.15
K_2O	......	......	......	1.09	.91	.18
Na_2O	......	......	......	.09	.04	.05
H_2O-	.05	.10	1.08	.09	Undet.	Undet.
H_2O+				.49	.15	.34
P_2O_5	Trace.	Trace.	......	.03	None.	.03
CO_2	39.18	43.16	42.72	41.85	None.	41.85
	99.56	99.94	99.43	100.63	10.00	90.54

NORTH CAROLINA AND SOUTH CAROLINA.

A. Marble, from Marshall, Madison County, N. C.

B. Marble, from Bakersville, N. C. Analyses A, B, by E. C. Sullivan, record No. 2157.

C. Marble, from Fletcher, Buncombe County, N. C. Analysis (partial) by G. Steiger, No. 2209. CO_2 calculated to satisfy bases.

D. Marble, from Caney Fork, Jackson County, N. C. Partial analysis by W. T. Schaller, No. 2259. CO_2 calculated.

E. Marl, Charleston, S. C. Analysis by W. F. Hillebrand, record No. 2187.

	A	B	C	D	E
Insoluble	....	.12	.13	....	....
SiO_2	13.20	....	....	16.45	10.92
Al_2O_3	1.82	.11	....	7.06	1.47
Fe_2O_3	.42		....	2.80	.75
FeO	.82	....	....	....	....
MgO	1.09	21.43	2.62	.25	.91
CaO	47.35	30.67	53.15	39.91	45.55
Na_2O	.32	....	....	....	.27
K_2O	.42	....	....	....	.38
H_2O-	.26	.13	....	....	[a] 3.17
H_2O+	.11	.14	....	....	
TiO_2	....	....	....	....	.08
CO_2	34.06	47.55	44.32	31.64	34.42
P_2O_5	.05	....	....	....	1.29
SO_3	Trace.	....	....	....	.54
F	....	....	....	....	.16
MnO	.05	....	....	....	Trace.
	99.97	100.15	100.22	98.11	99.91

[a] Includes organic matter.

GEORGIA.

A. Marble, Happy Valley.
B. "Creole" marble, Happy Valley.
C. Portion of B insoluble in dilute hydrochloric acid.
D. "Cherokee" marble, Happy Valley.
E. Portion of D insoluble in dilute hydrochloric acid.
Analyses by L. G. Eakins, record Nos. 464. 485.

	A	B	C	D	E
Insoluble	....	1.84	....	2.01	....
SiO_2	2.23	....	58.21	....	55.48
Al_2O_3	.91	.17	7.37	.15	15.58
Fe_2O_3	.22	....	....	....	....
FeO	....	.05	.31	.06	Trace.
CaO	52.16	53.91	12.53	53.69	14.52
MgO	2.09	.83	20.42	.83	12.88
H_2O	.45	.13	....	.17	....
CO_2	42.22	43.16	....	43.13	....
	100.28	99.69	98.84	100.04	98.46

FLORIDA.

1. CORAL AND SHELL ROCKS, COLLECTED BY N. S. SHALER.

Partial analyses only. Chlorides and sulphates present; alkalies and phosphates not looked for.

A, B, C, D. Coquina gravel, Tortugas.
E. The same, Key West.
F. Near Fort Worth.
G. East side of St. Johns River, near Seville.
H. Corroded surface, Miami Reef.
I. Near Oak Hill.
J. Near Melborne.
Analyses A to J by F. W. Clarke, record No. 885.

	A	B	C	D	E	F	G	H	I	J
SiO_2	0.19	0.22	0.32	0.21	0.25	2.94	8.50	2.99	5.87	17.83
Al_2O_3, Fe_2O_3	.19	.47	.56	.76	.56	.23	.73	.65	.95	1.18
CaO	52.24	51.24	49.38	51.95	51.52	51.51	47.29	51.22	50.34	43.85
MgO	1.53	2.09	1.93	1.44	2.08	.71	1.51	.06	.37	.26
CO_2	41.46	41.07	40.39	41.53	41.58	41.59	39.00	41.22	39.62	34.31
H_2O	3.27	3.57	5.12	3.07	3.19	2.64	3.37	2.23	3.21	2.53
	98.88	98.66	97.70	98.96	99.18	99.62	100.40	98.37	100.36	99.96

K. Coarse shell mass, Senote.

L. Coral rock, Salt Key Bank.

M. Loggerhead Key.

Analyses by L. G. Eakins, record No. 882. The following analyses, also by Eakins, No. 883, are included for comparison:

N. Coralline bottom, Barbados.

O. Recent coral (Siderastrea), Bermuda.

	K	L	M	N	O
SiO_2	0.22	0.11	0.20	1.17	0.23
Al_2O_3	.18	.04	.22	.31	Trace.
Fe_2O_3					
CaO	54.87	53.54	53.54	46.45	55.16
MgO	.64	.71	.78	5.15	.20
CO_2	43.89	43.87	43.71	43.40	43.74
H_2O	.11	1.13	.81	2.73	.54
	99.91	99.40	99.26	99.21	99.87

2. MISCELLANEOUS ROCKS.

A to M, inclusive. Thirteen borings from the artesian well at Key West. Partial analyses by Steiger, record No. 1553. The figures at tops of columns give depths in feet from which samples were taken. For a description of the limestones see E. O. Hovey, Bull. Mus. Comp. Zool., vol. 28, p. 63.

	A	B	C	D	E	F
	25	100	150	350	600	775
SiO_2	0.17	0.25	0.12	3.52	5.10	0.13
Al_2O_3	.20	.17	.08	.40	.35	.14
Fe_2O_3	.07	.07				
CaO	54.03	54.01	54.38	51.46	48.87	46.53
MgO	.29	.77	.86	1.67	2.50	6.70
CO_2	42.52	42.84	43.36	41.77	40.72	43.60
	97.28	98.11	98.80	98.82	97.54	97.10

	G	H	I	J	K	L	M
	1125	1325	1400	1475	1625	1850	2000
SiO_2	0.05	0.07	0.19	0.06	0.05	0.03	0.07
Al_2O_3, Fe_2O_3	.21	.11	.16	.14	.17	.17	.16
CaO	53.84	54.49	55.12	54.48	53.90	54.28	54.02
MgO	.86	.62	.30	.73	1.14	1.12	1.06
CO_2	42.87	43.29	43.28	43.38	43.37	43.13	43.20
	97.83	98.58	99.05	98.79	98.63	98.73	98.51

P_2O_5 is present. Is included with Al_2O_3 and Fe_2O_3.

N. Supposed cement rock, River Junction, received from D. T. Day. Analysis by George Steiger, record No. 1844.

O. Oolite, Boca Grande Key.

P. Oolite, Everglades.

Q. Bottom sample, east side of Marquesas Lagoon. Analyses O, P, Q are of samples collected by T. Wayland Vaughan. Analyzed by W. C. Wheeler, Nos. 2802, 2805.

	N	O	P	Q
SiO_2	12.31	0.03	[a] 8.23	1.13
Al_2O_3	2.19	.18	None.	.14
Fe_2O_3	.66	.22	.21	.21
MgO	16.72	Trace.	Trace.	1.31
CaO	26.28	53.77	51.60	51.04
Na_2O	.50	.90	.11	....
K_2O	None.	Trace.	Trace.	....
H_2O-	.94	1.21	.17	[b] 2.03
H_2O+	2.05			
CO_2	38.12	42.34	40.11	41.50
P_2O_5	.05	Trace.	Trace.	....
SO_3	....	.28	Trace.	....
Cl	....	1.02	.08	....
Soluble salts	....	....	....	2.21
	99.82	99.95	100.51	99.57

[a] Sand, 7.98, soluble silica, 0.25.

[b] Including organic matter.

The following samples were also collected by Vaughan. Analyses, partial only, by Wheeler, record No. 2805. CO_2 calculated to satisfy bases.

R. Beach sand, Sand Key.

S. From mud flat, Loggerhead Key.

T. Bottom sample, Fort Jefferson Channel.

U. Bottom sample, 60 fathoms, south of Sand Key.

	R	S	T	U
Insoluble	1.15	1.04	1.11	1.32
CaO	51.77	47.86	51.02	46.76
MgO	1.73	1.22	1.77	2.14
CO_2	42.55	38.93	42.01	39.07
Moisture, 150°	.44	6.77	Undet.	3.20
	97.64	95.82	95.91	92.49

KENTUCKY.

A. Lithographic stone, 1 mile from Brandenburg, Meade County, on Ohio River.

B. Typical lithographic stone from Solenhofen, Bavaria. Analyzed for comparison with A. Analyses by George Steiger, record No. 1894.

		A	B
SiO_2	Residue insoluble in HCl.	3.15	1.15
Al_2O_3, Fe_2O_3		.45	.22
CaO		.09	Trace.
		3.69	1.37
Al_2O_3		.13	.23
FeO		.31	.26
MgO		6.75	.56
CaO		44.76	53.80
Alkalies		.13	.07
H_2O-		.41	.23
H_2O+		.47	.60
CO_2		43.06	42.60
SO_3		None.	None.
		99.71	99.90

TENNESSEE, ALABAMA, AND LOUISIANA.

A. Limestone, east Tennessee mine, Ducktown, Tenn. Collected by W. H. Emmons. Analysis by W. T. Schaller, record No. 2537. Sp. gr., 2.81.

B. Limestone, Knoxville, Tenn. Analysis by L. G. Eakins, record No. 1159.

C. Knox dolomite, Morrisville, Ala. Described by Russell in Bull. 52, together with a residual clay derived from it. See section on clays. Analysis by W. F. Hillebrand, record No. 797.

D. Limestone from Raybom's salt lick, Bienville Parish, La. Analysis by R. B. Riggs, record No. 323.

E. White marble, streaked with black. From 5 miles west of Winfield, La. Analysis by W. F. Hillebrand, record No. 760. In addition to the constituents named in the table, this marble contains traces of barium, strontium, chlorine, and organic matter.

	A	B	C	D	E
Insoluble					.65
SiO_2	2.77	.17	3.24	.55	
Al_2O_3	.38	.04	.17	1.61	Trace.
Fe_2O_3		.23	.17		
FeO	1.85		.06		Trace.
MgO	1.89	.30	20.84	.06	.60
CaO	51.29	55.47	29.58	54.09	55.01
Na_2O	.13				
K_2O	Trace.				
H_2O	Trace.	.21	.30		.13
TiO_2	.04				
CO_2	40.84	43.63	45.54	44.12	43.43
P_2O_5	Trace.			.05	
SO_3				.05	.27
MnO	.30			Trace.	.10
FeS_2	.66				
	100.15	100.05	99.90	100.53	100.19

MISSISSIPPI.

Limestones received from E. C. Eckel. Partial analyses by H. C. McNeil, record No. 2181. CO_2 calculated to satisfy bases.

A. From Macon.
B. From Scooba.
C. From Border Creek.
D. From Wahulak Creek.
E. From Prairie Rock.
F. Selma chalk from north of Macon.
G. From Lime Creek.

	A	B	C	D	E	F	G
SiO_2	9.09	16.48	10.60	20.00	1.13	8.52	8.06
Al_2O_3, Fe_2O_3	7.47	6.97	5.90	8.92	.68	6.60	5.94
MgO	None.	.33	Trace.	Trace.	Trace.	None.	None.
CaO	45.38	41.64	46.21	38.61	54.55	47.00	47.41
H_2O	1.08	.67	.82	1.03	.40	1.00	1.32
CO_2	35.61	33.04	36.26	30.30	42.81	36.88	37.20
	98.63	99.13	99.79	98.86	99.57	100.00	99.93
Insoluble	14.59	20.96	14.21	25.79	1.36	10.00	10.28

TEXAS.

Supposed cement rock, Uvalde quadrangle. Collected by T. Wayland Vaughan. Analysis by W. F. Hillebrand, record No. 1759.

A, the rock; B, the part insoluble in dilute nitric acid.

	A		B
SiO_2	.10	SiO_2	20.80
Fe_2O_3, Al_2O_3	.09	Al_2O_3 Fe_2O_3 P_2O_5	3.44
CaO	40.82		
MgO	.18		
CO_2	32.41	H_2O	1.14
Insoluble	25.57	Alkalies	.19
NaCl, Mn, H_2O [a]	.83		25.57
	100.00		

[a] By difference.

OHIO.

A, B, C, D. Trenton limestone from New Vienna.
E. Trenton limestone, Arcadia, Hancock County.
F. Air-line Junction, Toledo. This sample contains a great deal of ferrous carbonate.
G. Gas rock, St. Henry's well, Mercer County.
H. Oil rock, Lima.

All Trenton. Partial analyses by F. W. Clarke and R. B. Riggs, record Nos. 729, 730, 732. Iron and alumina are present in soluble form.

	A	B	C	D	E	F	G	H
Insoluble	8.47	9.93	2.12	28.43	8.56	3.52	2.27	1.64
CaO	47.16	49.04	51.18	23.00	47.17	30.64	50.34	32.24
MgO	1.52	.58	3.08	12.90	2.59	18.05	2.86	17.36
CO_2	36.20	37.64	42.04	30.82	38.54	42.82	40.96	43.92
	92.35	97.19	98.42	95.15	96.86	95.03	96.43	95.16

The following partial analyses by F. W. Clarke, record No. 738, all relate to Trenton limestones:

A. Well No. 3, Bryan. Gas rock.
B. McElree well, Kenton. Depth, 1,315 feet.
C. Huntsville. Depth, 1,405 feet.
D. Prospect. Depth, 1,650 feet.
E. Findlay Street well, Dayton. Depth, 975 feet.
F. Xenia. Depth, 1,075 feet.
G. New Madison. Depth, 1,150 feet.

	A	B	C	D	E	F	G
Insoluble	9.22	5.26	4.41	26.12	12.34	9.23	11.11
Fe_2O_3, Al_2O_3	1.51	1.10	3.15	2.57	.58	.18	3.60
$CaCO_3$	49.00	84.32	57.23	66.02	82.36	86.54	64.91
$MgCO_3$	38.50	8.43	33.16	3.77	1.67	2.99	17.98
	98.32	99.11	98.95	98.58	96.95	98.94	97.60

In C and G there is ferrous carbonate.

Partial analyses by Charles Catlett, record Nos. 754, 755, 756, 757; all of Trenton limestones from the natural-gas belt.

A. London. Depth, 1,594 feet.
B. Air-line Junction, Toledo. Depth, 1,415 feet.
C. Celina. Depth, 1,112 feet.
D. City well No. 2, Upper Sandusky.
E. Sandusky. Depth, 2,260 feet.
F. Gas rock. Pauck well, St. Marys Township, Auglaize County.
G. Gas rock. Bennett well, St. Marys Township. Depth, 1,121 feet.
H. First city well, Carey. Depth, about 1,350 feet.
I. Well No. 2, Fort Recovery. Depth, 1,065 feet.
J. Waggoner well, 6 miles west of Fremont. Gas rock.
K. Loomis and Nyman well, Tiffin. Depth, 1,470 to 1,481 feet.
L. Loomis and Nyman well, Tiffin. Depth, 1,488 to 1,494 feet.
M. Port Clinton. Depth, 1,660 to 1,700 feet.
N. Wauseon. Depth, 2,135 feet.
O. Napoleon. Depth, 1,830 feet.
P. Kossuth, Allen County. Oil rock.
Q. Doenze's well, Franklin Township, Mercer County. Depth, 1,107 feet.

	A	B	C	D	E	F	G	H	I
Insoluble	15.90	2.88	2.95	8.18	3.65	3.18	1.66	5.72	1.89
Al_2O_3, Fe_2O_3	1.84	8.68	2.95	4.31	4.58	3.12	2.48	3.08	1.57
$CaCO_3$	77.69	54.68	68.41	64.25	54.62	52.18	56.94	80.11	87.88
$MgCO_3$	1.89	25.73	24.18	15.93	33.67	38.42	35.55	8.09	7.43
	97.32	91.97	98.49	92.67	96.52	96.90	96.63	97.00	98.77

	J	K	L	M	N	O	P	Q
Insoluble	5.22	5.66	9.88	7.46	18.24	2.66	1.08	3.68
Al_2O_3, Fe_2O_3	6.32	4.86	1.46	4.16	7.28	2.14	.66	8.38
$CaCO_3$	52.93	52.89	79.39	71.96	42.82	53.85	90.72	69.53
$MgCO_3$	32.75	33.46	6.20	14.34	28.11	37.33	6.69	10.98
	97.22	96.87	96.93	97.92	96.45	95.98	99.15	92.27

INDIANA.

A. Buff limestone, Hoosier Stone Co., Bedford.
B. Blue limestone, same locality.
Analyses by F. W. Clarke, record Nos. 306, 307.

	A	B
SiO_2	0.63	1.69
Fe_2O_3	.39	.49
CaO	54.19	54.18
MgO	.39	.37
P_2O_5	Trace.	Trace.
CO_2	44.01	43.06
SO_3	None.	None.
	99.61	99.81

The following Trenton limestones are all from the natural-gas belt:

C. Union City. Depth, 1,160 feet.
D. Bluffton. Depth, 1,062 to 1,067 feet.
E. Muncie. Depth, 920 feet.
F. Greensburg. Depth, 867 feet.
G. Vernon. Depth, 905 feet.
H. Wabash. Depth, about 900 feet.

Analysis C by F. W. Clarke, record No. 738. The remainder by Charles Catlett, Nos. 753, 758.

	C	D	E	F	G	H
Insoluble	2.14	2.37	3.30	0.87	8.00	3.52
Al_2O_3, Fe_2O_3	1.23	4.48	3.72	.55	.60	7.58
$CaCO_3$	83.21	53.43	51.96	94.60	85.56	53.18
$MgCO_3$	12.48	37.47	38.11	.36	Trace.	30.53
	99.06	97.75	97.09	96.38	94.16	94.81

MISSOURI.

Limestones and dolomites collected by W. P. Jenney. Analyses by L. G. Eakins, record Nos. 1184, 1207. CO_2 calculated.

A, B. Cherokee limestone, quarry near Seneca, Newton County.
C, D. The same, near Grand Falls, Newton County.
E, F. Dolomite, Oswego land, Joplin.

	A	B	C	D	E	F
Insoluble	0.66	1.21	1.01	1.01	29.77	11.66
Al_2O_3	.11	.13	.08	.13	1.32	1.03
FeO	.08	.07	.05	Trace.		
MnO	Trace.	Trace.	.03	Trace.	....	....
CaO	55.29	54.92	54.98	55.11	21.46	28.72
MgO	.23	.20	.31	.32	14.79	17.26
CO_2	43.69	43.31	43.54	43.65	33.13	41.55
	100.03	99.84	100.00	100.22	100.47	100.22

KANSAS.

A. Limestone, Silverdale. Analysis by Charles Catlett, record No. 967.

B. Cherokee limestone, Short Creek, near Spring River, Cherokee County. Analysis by L. G. Eakins, record No. 1184.

C. Supposed marl, large surface deposit near Wakeeney, Trego County. Analysis by F. W. Clarke, record No. 212.

D. Limestone, SE. ¼ sec. 13, T. 28 S., R. 12 E. Analysis by G. Steiger, record No. 2295.

	A	B	C	D
Insoluble	....	.32	....	....
SiO_2	5.27	....	14.06	2.56
Al_2O_3	1.07	.17	....	1.55
Fe_2O_3	.71	....	5.10	.50
FeO	.32	.20	....	.47
MnO	....	.02	....	....
CaO	50.36	55.25	43.05	51.98
MgO	.56	.35	.50	.06
K_2O	.10	....	....	....
Na_2O	.20	....	....	....
H_2O	.78	....	1.77	1.36
P_2O_5	.06	....	....	....
CO_2	40.34	43.79	35.03	41.13
SO_3	.07	....	....	....
	99.84	100.10	99.51	99.61

MICHIGAN, WISCONSIN, MINNESOTA, CANADA.

Most of the rocks considered under this heading were described by Irving and Van Hise in Mon. XIX, pages 131 and 191. A few other analyses, also representing Van Hise's collections, are taken from the laboratory records. The Canadian rocks are from near the boundary line, and relate directly to others gathered upon the Minnesota side.

A. Dolomite, near Sunday Lake, Gogebic district, Michigan. Analysis by W. F. Hillebrand, record No. 767.

B. Dolomite, Penokee region, Wisconsin, NW. ¼ sec. 22, T. 44 N., R. 5 W. Analysis by Hillebrand, record No. 768.

C. Limestone, bed of Slate Creek, Huron Bay slate quarries, Michigan. Analysis by T. M. Chatard, record No. 894. From laboratory records; not in the monograph cited.

D. Limestone, east end of Ogiskemannissi Lake, Minn. Analysis by Chatard, record No. 899. Not in monograph.

	A	B	C	D
SiO_2	3.07	.63	7.05	41.99
Al_2O_3	......	......	.48	1.24
Fe_2O_3	.09	.03	1.33	.42
FeO	.86	.75	Undet.	4.77
MnO	.15	.08	.19	.26
CaO	29.72	30.94	50.08	16.85
MgO	19.95	20.68	.57	8.41
H_2O-	.30	.27	......	.05
H_2O, ignition			.25	1.02
P_2O_5	......	......	.27	.05
CO_2	45.31	46.27	39.68	24.70
SO_3	......	......	.21	.32
Cl	Trace.	Trace.	......	......
	99.45	99.65	100.11	100.08

E. Iron carbonate, SE. ¼ sec. 20, T. 47 N., R. 43 W., Michigan.

F. Iron carbonate, south side of Sunday Lake, Mich.

G. Iron carbonate, Palms mine, Gogebic district, Michigan.

Analyses E, F, and G by W. F. Hillebrand, record Nos. 769, 770, 771.

H. Iron carbonate, Miner & Wells option, sec. 13, T. 47 N., R. 46 W., Michigan. Analysis by T. M. Chatard, record No. 893.

I. Iron carbonate, NW. ¼ sec. 18, T. 47 N., R. 45 W., Michigan. Analysis by Chatard, No. 895.

	E	F	G	H	I
SiO_2	3.16	28.86	46.47	46.01	36.73
TiO_2	......	.20	.10	.12	.19
Al_2O_3	.08	1.29	.70	.83	.38
Fe_2O_3	.93	1.01	.86	1.35	.98
FeO	15.18	37.37	28.57	26.07	34.81
MnO	1.15	.97	.40	2.09	.52
CaO	26.65	.74	.49	.63	.48
MgO	11.01	3.64	2.30	2.86	2.74
H_2O-	.54	.68	.60	1.71	.12
H_2O, ignition					1.40
P_2O_5	.06	Trace.	Trace.	.07	.01
CO_2	41.10	25.21	19.24	17.72	22.44
SO_3	......	......	......	.15	.16
Cl	Trace.	......	(?)	......	......
FeS_2	.34	......	......	......	......
	100.20	99.97	99.73	99.61	100.96

J. Iron carbonate, Penokee iron range, NE. ¼ sec. 6, T. 45, R. 2 E., Wisconsin. P. R. C. 999.

K, L. Black, slaty, carbonaceous iron carbonates, Animikie formation, Kakabikka Falls, Kaministiquia River, Canada.

M. Iron carbonate, west end of Gunflint Lake, Minn.

N. Iron carbonate, north side of Gunflint Lake, Minn.

O. Iron carbonate, north side of Gunflint Lake, Canada.

Analyses, J, K, and L by R. B. Riggs, record Nos. 376, 377, 378; M, N, and O by T. M. Chatard, record Nos. 897, 898, 900. Rocks M, N, and O are described by Clements in Mon. XLV, p. 380.

	J	K	L	M	N	O
SiO_2	15.62	37.73	54.26	58.23	46.46	23.90
TiO_2				Trace.	Trace?	None.
Al_2O_3	4.27	3.41	2.57	.06	.24	.07
Fe_2O_3	8.14	6.42	3.62	5.01	.64	.44
FeO	32.85	22.92	19.63	18.48	26.34	10.72
MnO	5.06	.40	.19	.25	.21	.28
CaO	.81	1.26	1.07	.38	1.87	22.25
MgO	2.66	3.98	2.93	9.59	3.10	8.52
H_2O-	.68	2.74	1.20	.07	.07	None.
H_2O+				2.01	1.15	.99
P_2O_5				.03	.13	Trace.
CO_2	30.32	18.01	14.93	5.22	19.96	32.42
SO_3				.19	.14	.17
C		3.54	.45			
	100.41	100.41	100.85	99.52	100.31	99.76

P. Ferrodolomite, Marquette district, Michigan. Analysis by George Steiger, record No. 1473. P. R. C. 994.

Q. Ferrodolomite, Marquette district, Michigan.

R. Portion of Q insoluble in hydrochloric acid.

S. Soluble portion of Q.

Analyses Q, R, and S by George Steiger, record No. 1442. These analyses are not in the monograph cited.

T. Ferruginous dolomite, Hamburg Hill, Menominee district, Michigan. Described by Bayley in Mon. XLVI, p. 480. Analysis by George Steiger, record No. 2033.

	P	Q	R	S	T
SiO_2	42.37	26.97	26.67	0.30	36.71
Al_2O_3		1.30	.12	1.18	5.34
Fe_2O_3	1.09	2.31	.16	2.15	.35
FeO	31.41	39.77		39.77	3.37
MgO	2.48	1.94	.10	1.84	10.78
CaO	.50	.66		.66	15.11
Na_2O		.09		.09	.12
K_2O					2.40
H_2O-		.10			.55
H_2O+		.51			1.61
TiO_2					.27
CO_2	21.80	26.20		26.20	23.22
P_2O_5		.03		.03	.05
MnO		.29		.29	.23
	99.65	100.17	27.05	72.51	100.11

The three following analyses, by E. C. Sullivan, record No. 2160, are of material collected in Michigan by I. C. Russell:

U. Marl, Ore Lake.

V. Dolomite, Maybee, tenth layer from top.

W. Like V, fifth layer from top.

	U	V	W
SiO_2	0.53	1.77	1.30
Al_2O_3	.14	.01	.16
Fe_2O_3[a]	.96	.41	.20
MgO	1.10	20.84	19.79
CaO	51.87	29.65	31.14
Na_2O	.10	....	....
K_2O	.10	....	....
H_2O-	.97	.12	.18
H_2O+	1.22	.48	.57
CO_2	42.30	46.40	43.18
P_2O_5	.06	Trace.	Trace.
SO_3	.14	.33	1.15
MnO	Trace.	Trace.	Trace.
	99.49	100.01	99.67

[a] Total iron.

SOUTH DAKOTA AND WYOMING.

A. Purple limestone, east of Cascade, Black Hills, S. Dak. Collected by G. B. Richardson. Analysis by George Steiger, record No. 1854.

B. Dolomite from the Tornado mine, Black Hills. Received from S. F. Emmons. Analysis by W. F. Hillebrand, record No. 1866.

C. Limestone, Hunt Mountain, Bighorn district, Wyo. Received from N. H. Darton. Partial analysis by Hillebrand, No. 2250. CO_2 calculated to satisfy bases.

D. Niobrara limestone, west of Laramie, Wyo.

E. Chalk, 3 miles southwest of Rock Creek station, Wyo. Rocks D, E, received from N. H. Darton. Analyses, partial only, by R. C. Wells, No. 2387.

F. Dolomite, Bull Creek canyon, Wind River Mountain, Wyo. Received from E. Blackwelder. Analysis, partial, by J. G. Fairchild, No. 2530.

	A	B	C	D	E	F
Insoluble	....	....	.24	22.87	7.57	....
SiO_2	1.12	5.74	....			2.30
Al_2O_3	.36	2.02	.08	1.81	.98	1.50
Fe_2O_3		.64				
FeO		6.47	....	....	....	....
MgO	19.85	14.75	19.44	Trace.	None.	20.19
CaO	31.51	26.81	32.95	39.83	50.10	29.35
Na_2O	None.	.07	....	....	....	....
K_2O	None.	.53	....	....	....	....
H_2O-	.07	.34	....	....	....	....
H_2O+	1.18	.67	....	....	....	....
CO_2	45.66	40.11	47.26	31.00	38.63	45.60
P_2O_5	....	.08	....	....	....	....
SO_3	.07	....	....	....	....	....
FeS_2	....	.69	....	....	....	....
MnO	None.	.97	....	....	....	....
	99.82	99.89	99.97	95.51	97.28	98.94

YELLOWSTONE NATIONAL PARK.

Travertines, tufas, and calcareous sinters. Analyses A to E reported by W. H. Weed in 9th Ann., p. 619. Travertines.

A. Terrace below the hotel.

B. Cupids Cave.

C. Near Sulphur Spring No. 246, Mammoth Hot Springs.

D. Extinct spring, main terrace, Mammoth Hot Springs.

E. Ridge behind main terrace.

Analysis C by F. A. Gooch, record No. 243; A, B, D, and E by J. E. Whitfield, record Nos. 240, 242, 244, 245.

	A	B	C	D	E
SiO_2	0.08	0.15	0.01	0.06	0.26
Al_2O_3	.15	.49	.05	.14	.11
Fe_2O_3					
CaO	53.83	53.41	55.02	55.02	54.06
MgO	.90	.42	.07	.06	.66
K_2O		.01	.04		
Na_2O		.03			
H_2O	1.43	2.44	1.61	1.06	1.19
NaCl	.02	.13	.12	.20	.26
KCl				.08	
SO_3	1.72	.55	.49	.70	1.34
CO_2	41.79	41.96	42.25	42.25	42 14
C (organic)	.21	.37	.11	.24	None.
	100.13	99.66	99.77	99.81	100.02

Analyses F, I, and J, by F. A. Gooch, record Nos. 93, 246, 257; G, H, and K, by J. E. Whitfield, record Nos. 239, 241, 862.

F. Calcareous tufa, Mammoth Hot Springs.

G. Travertine, from cavity near Pulsating Geyser, Mammoth Hot Springs.

H. Travertine, from bank of Hot River.

I. Travertine, from edge of old cave, highest terrace, Mammoth Hot Springs.

J. Travertine, capping Terrace Mountain, Mammoth Hot Springs.

K. Calcareous sinter, Hot Lakes. Sp. gr., 2,857.

	F	G	H	I	J	K
SiO_2	0.05	0.05	0.67	0.03	0.09	1.52
Al_2O_3, Fe_2O_3	.06	.11	.19	.04	.11	Traces.
CaO	55.34	52.46	53.89	55.64	55.37	54.26
MgO	.26	.90	.78	.19	.35	Trace.
MnO						.29
K_2O		.71		Trace.	.04	
Na_2O		.33				
NaCl	.03	1.45	.06	.09	.10	
CO_2	42.78	40.88	41.95	43.35	43.11	40.76
P_2O_5	Trace.					
SO_3	.32	1.82	1.25	.24	.44	Trace.
H_2O	1.37	[a] 1.02	[a] 1.27	[a] .45	[a] .32	2.89
C (organic)	.04	.30	.26	.14	.17	
H (organic)	.02					
	100.27	100.03	100.32	100.17	100.10	99.72

[a] Includes H of organic matter.

MONTANA.

Rocks A to H collected by A. C. Peale. Analyses by Charles Catlett, record Nos. 890, 905.

A. North of East Gallatin River.

B. West of North Boulder River.

C, D. North of East Gallatin River.

E. Base of Carboniferous, west side of Bridger Range.

F. Middle Carboniferous, north of Gallatin River.

G, H. Upper Carboniferous, north of Gallatin River.

Analyses all partial. A, B, C, D, and H were published by Peale in Bull. 110, pp. 16, 28, and 40.

	A	B	C	D	E	F	G	H
Insoluble	0.34	1.78	23.50	35.26	9.98	5.99	50.74	25.24
Fe_2O_3, Al_2O_3	.22	.40	2.50	1.92	.38	.58	.30	5.30
$CaCO_3$	54.54	54.54	67.85	59.11	88.50	91.96	32.28	40.21
$MgCO_3$	43.63	42.62	6.18	1.96	.95	1.35	13.91	25.25
	99.73	99.34	100.03	98.25	99.81	99.88	97.23	96.00

I. Marble, Elkhorn district. Collected by W. H. Weed. Analysis by E. C. Sullivan, record No. 2195.

J. Impure magnesian limestone, near Georgetown Lake, Philipsburg quadrangle. Collected by F. C. Calkins. Analysis by W. T. Schaller, No. 2498.

	I	J
SiO_2	9.18	44.80
Al_2O_3	1.20	8.96
FeO (total iron)	.66	2.85
MgO	.12	5.90
CaO	52.35	16.42
K_2O	.36	2.14
Na_2O	....	.43
H_2O-	.59	3.33
H_2O+	.24	
TiO_2	....	.37
CO_2	35.46	15.42
	100.16	100.62

IDAHO.

A. Marble, Orofino.

B. Limestone, Missouri Creek, Nez Perce County. Analyses A and B by W. F. Hillebrand, record No. 1905.

C. Limestone, Montpelier.

D, E. Limestones, Georgetown. Rocks C, D, E, collected by R. W. Richards. Analyses by W. C. Wheeler, No. 2794.

F. Limestone, Snake River Canyon. Analysis by G. Steiger, No. 1909.

	A	B	C	D	E	F
Insoluble	0.64	1.19	....	....	....	0.36
SiO_2	....	....	2.55	15.06	10.41	....
Al_2O_3	.12	.19	.43	2.03	3.57	.10
Fe_2O_3			.44	.68	1.41	
MgO	3.05	.51	1.35	.55	1.69	.10
CaO	51.96	54.75	51.96	44.76	44.39	55.34
CO_2[a]	44.08	43.50	41.08	35.89	37.01	43.59
Organic matter	Trace.	Trace.	....	....	....	....
Ignition	....	....	1.80	.60	1.00	....
	99.85	100.14	99.61	99.57	99.48	99.49

[a] Calculated to satisfy bases.

Rocks G to J, from Empire Copper deposits, near Mackay. Collected by J. B. Umpleby. Analyses, partial only, by W. C. Wheeler, record No. 2851.

	G	H	I	J
SiO_2	11.02	3.92	1.67	2.84
Al_2O_3	.90	.72	.30	.18
Fe_2O_3	.24	.33	.25	.24
MgO	4.73	12.72	.48	1.03
CaO	47.39	42.14	53.71	54.14
CO_2	33.71	38.96	41.89	41.28
H_2O[a]	.97	.47	.49	.41
	98.96	99.28	98.79	100.12
Specific gravity	2.786	2.810	2.728	2.749

[a] Ignition, less CO_2.

COLORADO.

1. DENVER BASIN.

Rocks described by Emmons in Mon. XXVII. Analyses made by L. G. Eakins, in the Denver laboratory.

A. Upper Wyoming limestone, Morrison.

B. Niobrara dolomite.

	A	B
Insoluble	5.32	12.01
Al_2O_3	.53	.54
Fe_2O_3	.38	.11
MnO	.49	.20
CaO	48.73	27.49
MgO	2.95	18.03
H_2O	.11	.61
P_2O_5	.03	.03
CO_2	41.71	41.40
	100.25	100.42

2. LEADVILLE DISTRICT.

Rocks described by Emmons in Mon. XII. Analyses A and E by W. F. Hillebrand; B, C, and D by A. Guyard; all made in the Denver laboratory.

A. Upper blue limestone, Silver Wave mine.

B. Upper blue limestone, Dugan quarry.

C. Upper blue limestone, Glass-Pendery mine.

D. Montgomery quarry, near base of blue limestone.

E. White limestone, upper part, Carbonate Hill quarry.

Rocks F, G collected by J. D. Irving. Analyses by J. G. Fairchild, record No. 2666.

F. Blue limestone. Sp. gr., 2.774.

G. Manganosiderite, Tucson mine. Sp. gr., 3.503.

	A	B	C	D	E	F	G
SiO_2	0.21	0.70	0.27	7.76	11.84	0.34	10.08
Al_2O_3	.27	.17	.04	.11	1.66	.22	3.16
Fe_2O_3	.21	.11	.22	.10	1.51	.09	None.
FeO	.24	.38	.13	.57	.83	.71	26.80
MnO	Trace.	.05	.20	.06	....	.19	19.71
MgO	21.14	20.78	21.52	20.05	17.41	21.32	4.04
CaO	30.79	30.43	29.97	27.26	26.60	29.84	.08
Na_2O	.06	.09	.02	.04	.03	.59	.57
K_2O	.03	.05	.01	.02	.02	Trace.	.08
H_2O-	.22	.04	.07	.05	.48	.15	.22
H_2O+						.32	.89
TiO_2	....	....	....	....	....	None.	Trace.
CO_2	46.84	46.93	47.39	43.79	40.01	45.18	33.14
P_2O_5	Trace.	.12	.03	.07	Trace.	Trace.	.47
SO_3	Trace.	....	....	Trace.	....	....	....
Cl	.10	.14	.04	.06	.05	Trace.	....
FeS_2	Trace.	Trace.	....	Trace.	....	.35	.84
BaO	....	....	....	....	....	....	Trace.
Organic matter	.03	.03	.02	.07	....	.17	....
	100.14	100.02	99.93	100.01	100.44	99.47	100.08

3. FAIRPLAY, PARK COUNTY.

Analyses made by W. F. Hillebrand, in the Denver laboratory.

A. Serpentinous limestone, Buckskin Gulch.
B. Limestone, Fairplay.
C. Limestone, Mount Silverheels.
D. Dolomite-limestone, Mount Silverheels.

Analyses B, C, and D partial, with CO_2 calculated to satisfy bases.

	A	B	C	D
Insoluble	......	2.37	0.51	1.98
SiO_2	17.64	......	......	......
Al_2O_3	.99	......	......	......
Fe_2O_3	.62	......	......	......
FeO	.18	.19	.10	.46
MnO	Trace.			
CaO	32.23	53.64	55.50	30.19
MgO	19.01	.73	.17	20.47
Alkalies	.07	......	......	......
H_2O	3.72	.51	......	......
P_2O_5	.05	......	......	......
CO_2	25.33	42.93	43.82	46.52
Cl	.08	......	......	......
	99.92	100.37	100.00	99.62

4. PITKIN COUNTY.

Limestones and dolomites collected under the direction of S. F. Emmons. Analyses by George Steiger, record No. 1559. CO_2 calculated to satisfy bases. Analyses partial only.

	A	B	C	D	E	F	G
Insoluble	0.16	0.80	1.02	13.63	1.42	31.12	7.78
Fe_2O_3	.22	1.63	2.10	1.88	3.34	.36	.88
FeO	.09	.23	.06	.64	.42	.19	.22
CaO	30.66	31.19	33.74	35.98	31.61	37.28	38.85
MgO	20.94	19.69	16.76	8.25	18.06	.54	9.97
CO_2	47.13	46.16	44.94	37.35	44.70	29.88	41.47
	99.20	99.70	98.62	97.73	99.55	99.37	99.17

The following samples from Aspen were analyzed by L. G. Eakins in the Denver laboratory. Partial analyses, CO_2 calculated as before.

H. Blue limestone.
I. Limestone.
J. Dolomite.

	H	I	J
Insoluble	0.52	0.33	0.84
Fe_2O_3	.88	Trace.	1.31
CaO	31.16	55.81	30.46
MgO	20.64	.16	20.90
CO_2	47.19	44.03	46.92
	100.39	100.33	100.43

5. GLENWOOD SPRINGS, GARFIELD COUNTY.

Limestones and dolomites collected under the direction of S. F. Emmons. Analyses, partial only, by George Steiger, record No. 1559. CO_2 calculated to satisfy bases.

	A	B	C	D	E	F	G
Insoluble	21.45	47.74	6.47	3.71	9.44	17.82	1.96
Fe_2O_3	.97	.18	.42	None.	.26	.74	.03
FeO	.23	.71	.35	.55	.32	.57	.35
CaO	40.64	15.87	46.65	47.40	39.56	26.50	32.14
MgO	.73	10.60	2.64	4.49	8.56	14.86	18.72
CO_2	32.73	24.13	39.55	42.15	40.52	37.18	45.85
	96.75	99.23	96.08	98.30	98.66	97.67	99.05

	H	I	J	K	L	M
Insoluble	2.27	0.22	0.23	0.06	0.22	0.11
Fe_2O_3	.14	Trace.	.09	None.	.10	.03
FeO				None.	.10	.07
CaO	53.79	55.17	55.49	55.81	55.45	55.68
MgO	.46	.21	.24	Trace.	.24	Trace.
CO_2	42.76	43.58	43.87	43.85	43.84	43.75
	99.42	99.18	99.92	99.72	99.95	99.64

6. TENMILE DISTRICT, SUMMIT COUNTY.

Partial analyses, made in the Denver laboratory, by W. F. Hillebrand. CO_2 calculated to satisfy bases. Manganese and iron present as carbonates, but Fe_2O_3 and Al_2O_3 were not separated from them.

A. A. V. Fletcher shaft, Copper Mountain.
B. Pittston tunnel.
C. Middle Carboniferous, Pearl Hill.
D. Summit quarry.
E. Dolomite, Sheep Mountain.
F. Oolitic limestone, northwest corner of area.
G. Pittston tunnel.

	A	B	C	D	E	F	G
Insoluble	2.69	0.62	10.09	1.75	0.78	1.37	7.91
FeO, MnO	.21	.25	1.19	.32	1.50	.20	.32
CaO	54.23	55.24	28.01	53.60	30.55	55.17	50.83
MgO	.21	.24	18.33	1.23	20.15	.28	.70
CO_2	42.97	43.81	42.63	43.65	47.04	43.76	40.90
	100.31	100.16	100.25	100.55	100.02	100.78	100.66

H. Dolomite, Blackbird tunnel, Tucker Mountain.
I. Summit King shaft, Summit City.
J. Middle Carboniferous dolomite, Ptarmigan Hill.
K. Hill north of Sugar Loaf.
L. Quarry on southeast side of Searls Gulch.
M. Open cut below Sabbath Rest Tunnel, Elk Mountain.
N. Triassic, Jacque Mountain.

	H	I	J	K	L	M	N
Insoluble	2.68	6.75	0.65	4.42	0.36	0.82	2.04
FeO, MnO	1.52	3.08	1.67	.10	.17	.07	.15
CaO	31.60	28.05	30.90	52.97	55.58	55.47	54.62
MgO	18.27	18.15	19.75	.40	.37	.22	.25
CO_2	45.75	43.88	47.02	42.12	44.17	43.86	43.28
	99.82	99.91	99.99	100.01	100.65	100.44	100.34

7. RICO DISTRICT.

Limestone described by Ransome in 22d Ann., pt. 2. Analyses by W. F. Hillebrand, record No. 1914.

A. From Forest-Payroll mine.

B. Alteration product of A.

C. From Nellie Bly mine.

	A	B	C
SiO_2	23.51	29.29	0.80
Al_2O_3	1.56	12.56	.04
Fe_2O_3	.30	5.36	.07
FeO	.56		.10
MgO	2.29	14.21	.25
CaO	39.15	1.06	55.10
Alkalies	(?)	.20	
H_2O-	.51	7.33	
H_2O+	.66	[a]8.88	
TiO_2	.06	.27	Trace.
CO_2	[a]30.86	.17	[a]43.39
P_2O_5	Trace.	.14	Undet.
SO_3		Trace.	
S			Trace.
MnO	.54		.13
MnO_2		13.27	
BaO	Trace.	Trace.	None.
Li_2O		Trace.	
ZnO	Trace.	1.65	.09
CuO	Trace.	.40	.03
PbO_2		5.21	
	100.00	100.00	100.00

[a] By difference.

UTAH.

A. Marble from the Ontario mine, east end of the 1,000-foot level. Analysis made by L. G. Eakins in the Denver laboratory.

B. Oolitic sand from shore of Great Salt Lake. Analysis by T. M. Chatard, record No. 156.

	A	B
Insoluble in HCl	9.61	4.03
Al_2O_3	Trace.	.20
Fe_2O_3		
CaO	50.63	51.33
MgO	.09	.72
Alkalies		.63
CO_2	[a]39.89	41.07
P_2O_5		Trace.
SO_3		.89
H_2O		.83
Organic matter		.27
	100.22	99.97

[a] Calculated to satisfy bases.

The following samples, C to J, represent altered limestones from the Bingham district. Received from S. F. Emmons. Partial analyses by W. F. Hillebrand, record No. 1932.

C. White altered limestone, Emma mine, west drift.

D. Same locality as A, gray.

E. White altered limestone, Highland Boy mine, No. 7 tunnel.

F. Same locality as C, gray.

	C	D	E	F
SiO_2	50.41	12.50	43.40	4.87
Al_2O_3, Fe_2O_3	.30	1.99	....	.30
MgO	24.57	3.66	1.31	.99
CaO	9.74	48.34	45.52	53.50
H_2O	11.61	4.31	.23	....
CO_2	1.61	28.06	8.28	39.32
P_2O_5	.15	.56	....	....
MnO	Trace.	....	....	....
	98.59	99.42	98.74	98.98

G, H, I. Altered limestones from different points on West Mountain.
J. Altered limestone, Bingham Canyon.

	G	H	I	J
SiO_2	27.78	27.76	34.36	47.29
Al_2O_3	....	....	....	[a] 1.83
Fe_2O_3	....	....	....	3.46
MgO	.34	6.09	1.09	22.86
CaO	39.98	38.91	35.99	8.44
H_2O	....	....	....	14.04
CO_2	30.76	24.28	25.91	1.73
P_2O_5	....	....	....	.28
MnO	....	....	....	.15
	98.86	97.04	97.35	100.08

[a] With a little TiO_2.

The following rocks are from the Park City district. Collected by J. M. Boutwell. Partial analyses by G. Steiger, record No. 2207.
K. Daly West Mine.
L. Scottish Chief mine.
M, N. Silver King mine.

	K	L	M	N
SiO_2	3.81	1.90	1.50	4.54
Al_2O_3[a]	.19	1.70	.31	.64
Fe_2O_3	.38	1.62	.11	None.
FeO	.16	1.40	.16	.30
MgO	19.54	1.04	20.41	19.07
CaO	30.11	50.51	30.54	29.69
CO_2	44.78	39.66	46.03	44.27
TiO_2	....	.08	None.	.04
MnO	....	.70	.28	.25
	98.97	98.61	99.34	98.80

[a] Includes possible P_2O_5.

The following carbonate rocks and the altered rocks in contact with them (A to D) were collected by B. S. Butler in the San Francisco district. Analyses by G. Steiger, record No. 2444.
A. Limestone. Sp. gr., 2.72.
B. Altered rock in contact with A. Sp. gr., 3.56.
C. Dolomite. Sp. gr., 2.84.
D. Altered rock in contact with C. Sp. gr., 3.30.
E. Marl, Baker's Spur, old bed of Great Salt Lake. Received from E. S. Burchard. Partial analysis by J. G. Fairchild, record No. 2547.

	A	B	C	D	E
SiO_2	15.44	37.94	0.68	41.04	10.41
Al_2O_3	2.78	4.59	.18	13.37	2.41
Fe_2O_3	.20	21.09	.19	6.09	
FeO	1.00	.41	.27	1.01	....
MgO	7.62	1.79	21.16	3.32	3.13
CaO	35.05	33.20	30.78	31.28	42.18
Na_2O	.09	.17	.05	.15	1.41
K_2O				.46	.62
H_2O-	.03	.07	.30	.13	....
H_2O+	1.33	.22		.69	....
TiO_2	.20	.21	None.	.48	....
CO_2	35.65	.17	46.65	1.04	34.69
P_2O_5	.39	.06	Trace.	.12	....
SO_3	.06	.08	None.	.14	....
MnO	.34	.44	.05	1.07	....
NaCl	....	....	....	....	.88
	100.18	100.44	100.31	100.39	95.73

ARIZONA.

A. Fresh contact-metamorphosed limestone, Joy mine, Morenci district.

B. Primary alteration of A, adjoining pyrite vein.

Rocks A and B collected by W. Lindgren, and described in P. P. 43, p. 172. Analyses by W. F. Hillebrand, record No. 1997.

C. Representative "mineralized" limestone, Copper Queen mine, Bisbee.

D. Dark limestone, Copper Queen mine.

E. Alteration product of D. Partial analysis.

Rocks C, D, E, collected by F. L. Ransome. Analyses by W. F. Hillebrand, record No. 2036.

F. Devonian limestone, 4 miles north of Dripping Spring, Ray district. Also collected by Ransome. Partial analysis by R. C. Wells, No. 2611. CO_2 calculated to satisfy bases.

	A	B	C	D	E	F
SiO_2	17.08	42.03	28.55	32.88	58.88	3.11
Al_2O_3	2.34	3.16	.98	[a] 10.84	[a] 16.03	.33
Fe_2O_3	.76	1.18	None.	....	5.13	1.22
FeO	....	.84	.84	1.45	....	
MgO	12.38	20.25	13.62	13.93	4.27	18.65
CaO	32.48	10.41	26.20	15.78	.70	31.65
Na_2O	.09	.06	.14	.26	.12	....
K_2O	.10	.12	.06	2.19	10.29	....
H_2O-	.95	1.07	1.05	[b] 7.00	[c] 4.36	....
H_2O+	3.01	4.25	3.08			
TiO_2	.27	.31	.16	Undet.	Undet.	....
ZrO_2	.02	Trace.	....	....	....	....
CO_2	26.85	3.58	19.00	11.75	Trace.	45.20
P_2O_5	.16	.42	.54	Undet.	Undet.	....
SO_3	.13	.75	None.	....	....	....
MnO	.26	.18	.40	....	....	....
CuO	....	.83	Trace.	....	....	....
FeS_2	1.50	8.10	5.63	3.92	....	....
$CuFeS_2$	.18	1.67	....	....	....	....
Li_2O	Trace.	Trace.	Trace.	....	....	....
ZnO	.99	.58	....	....	....	....
	99.55	99.79	100.25	100.00	99.78	100.16

[a] Includes possible TiO_2 and P_2O_5.

[b] By difference.

[c] Loss on ignition.

NEVADA.

A. Crystalline limestone, Eureka. Analysis by E. A. Schneider, record No. 1279.

B. From base of the Hamburg limestone, Eureka district,

C. From summit of Hamburg limestone, Eureka.

D. Pogonip limestone (Silurian), Eureka district. Analyses B, C, and D made by W. F. Hillebrand in the Denver laboratory. Described by Hague in Mon. XX, pp. 40, 49. In D the CO_2 was taken by difference.

	A	B	C	D
Insoluble	0.53			
SiO_2		24.00	3.94	9.34
Al_2O_3		.12	.64	.31
Fe_2O_3		.12	.43	.29
FeO			.20	
MnO			.61	
CaO	30.60	41.97	51.96	50.01
MgO	21.69	.80	.52	.54
Alkalies		Traces.	Traces.	Traces.
H_2O-		.16	.37	.13
H_2O+				
P_2O_5		.07	.50	.24
CO_2	47.13	32.62	40.71	39.11
Organic matter		Trace.	.03	Trace.
Cl		.01	.01	.03
	99.95	99.87	99.92	100.00

E. Dolomite, 6.3 kilometers west of north from Red Mountain, Silver Peak district.

F. Dolomite, 16.3 kilometers northeast of Silver Peak village. Analyses E and F by George Steiger, record No. 1859.

G. White deposit, White Terrace, west shore of Pyramid Lake. Analysis by T. M. Chatard, record No. 34.

H. From Ash Meadow. Collected by H. S. Gale. Analysis by J. B. Hicks, record No. 2788.

	E	F	G	H
Insoluble	0.31	7.18		
SiO_2			22.00	0.58
Al_2O_3			5.14	None.
Fe_2O_3			2.04	.13
FeO	1.89	.95		
MgO	20.19	19.19	1.89	.19
CaO	30.35	28.52	37.22	55.17
H_2O			3.32	
CO_2	[a] 47.21	[a] 44.09	28.53	42.90
	99.95	99.93	100.14	98.97

[a] Calculated to satisfy bases.

CALIFORNIA.

A. Cretaceous limestone from Mount Diablo. Analysis by W. H. Melville in the San Francisco laboratory and published in Bull. Geol. Soc. America, vol. 2, p. 409. FeO and alkalies undetermined.

B. Green limestone, near Barstow, Mojave Desert.

C. Gray limestone, near Barstow. Rocks B, C, received from R. W. Pack. Analyses by G. Steiger, record No. 2771.

D, E. Calcareous clays, Panoche Hills.

F. Calcareous clay, foothills of the Diablo Range. Samples D, E, F, received from R. Anderson. Analyses partial only, by G. Steiger, No. 2551.

	A	B	C	D	E	F
SiO_2	21.19	21.63	2.02	19.84	9.74	21.11
Al_2O_3	.39	3.86	1.48	4.97	2.76	2.80
Fe_2O_3	1.52	.80	None.	1.95	1.65	.75
FeO		1.13	.30			
MgO	1.39	19.17	7.56	5.28	1.85	.56
CaO	35.61	26.18	45.89	34.06	45.48	40.23
Na_2O		None.	.02			
K_2O		None.	.23			
H_2O-	.76	.17	.02			
H_2O+	2.33	6.07	.51			
TiO_2		.26	None.			
CO_2	26.84	20.35	42.41	29.85	35.94	31.01
P_2O_5	2.55	.05	None.			
MnO	3.61					
Cr_2O_3		None.	None.			
	96.19	99.67	100.44	95.95	97.42	96.46

OREGON.

Limestones collected in western Oregon by J. S. Diller. Analyses by R. C. Wells, record No. 2381.

A. Ten and one-half miles southwest of Grants Pass.
B. Carter's quarry, 5¼ miles southeast of Gold Hill.
C. Householder's quarry, 5 miles southeast of Gold Hill.
D. Ridge southwest of Gold Hill.
E. Jones's marble quarry, 3 miles southwest of Williams.
F. Applegate River, near mouth of Manzanita Creek.
G. Three miles southeast of Kerby.

	A	B	C	D	E	F	G
SiO_2	0.23	0.37	0.31	23.86	0.13	0.53	0.06
Al_2O_3,Fe_2O_3	.28	.20	.44	.32	.38	.52	.62
CaO	55.28	55.71	55.34	41.83	55.55	55.05	55.38
MgO	.03	.01	.03	Trace.	None.	Trace.	Trace.
H_2O	.50	.37	.56	.46	.26	.50	.40
CO_2	43.57	43.54	43.23	32.57	43.63	43.25	43.51
	99.89	100.20	99.91	99.04	99.95	99.85	99.97

ALASKA.

Limestone, Jumbo mine, Prince of Wales Island.

Collected by C. W. Wright. Analysis by G. Steiger, record No. 2441.

SiO_2	0.61	TiO_2	Trace.
Al_2O_3	.30	CO_2	44.07
Fe_2O_3[a]	.48	S	.06
MgO	8.10	MnO	.03
CaO	46.45		
H_2O-	.06		100.32
H_2O+	.16		

BaO, SrO, P_2O_5, and alkalies absent.

---

[a] Total iron.

HAWAIIAN ISLANDS.

Coral and shell rocks, analyzed for N. S. Shaler by L. G. Eakins, record Nos. 886, 887, 889. Analyses only partial

A. Laie.
B, C. Kohuku Bluff.
D. Kohuku coral flat.
E. Point near coral flat.
F. "Modern chalk," Oahu.
G. Diamond Head.
H. Under lava, Honolulu.
I. Old reef, Waialua.
J. Campbell's ranch, Waianea, Oahu.
K. Wailuku Bay.
L. Reef No. 3, Honolulu.
M. Prison Knoll, Honolulu.

	A	B	C	D	E	F	G
SiO_2	0.35	0.19	0.67	0.25	0.26	33.25	2.97
Al_2O_3	.19	.52	.73	.49	.21	19.53	2.88
Fe_2O_3						10.71	
CaO	49.38	49.34	51.09	53.34	52.17	11.37	44.82
MgO	1.74	4.60	2.50	.67	1.51	3.06	5.32
CO_2	41.89	44.33	43.64	43.89	43.95	11.09	40.81
H_2O	4.74	.40	.79	.93	.70	9.84	1.86
	98.29	99.38	99.42	99.57	98.80	98.85	98.66

	H	I	J	K	L	M
SiO_2	5.34	1.05	0.53	0.45	3.53	0.81
Al_2O_3	5.11	1.26	.62	1.82	2.26	1.19
Fe_2O_3						
CaO	42.24	51.07	50.69	50.54	46.52	52.67
MgO	5.95	.11	2.98	1.83	2.45	.42
CO_2	38.71	42.68	43.96	42.80	40.59	42.81
H_2O	1.61	1.33	.46	1.93	2.75	1.24
	98.96	97.50	99.24	99.37	98.10	99.14

BAHAMAS.

Rocks collected by T. Wayland Vaughan. Analyses by W. C. Wheeler, record Nos. 2802, 2805, 2809.

A. Sharp Point, Andros Island.
B. Bottom sample.

	A	B
SiO_2	0.07	0.28
Al_2O_3	None.	.03
Fe_2O_3	.13	.11
MgO	Trace.	1.25
CaO	54.57	52.30
Na_2O	.14	....
K_2O	Trace.	....
H_2O	1.72	[a] 3.16
CO_2	43.07	42.45
SO_3	.14	....
Cl	.03	....
P_2O_5	Trace.	....
	99.87	99.58

[a] Includes organic matter.

The following analyses are only partial. CO_2 calculated to satisfy bases in all except the last one.

C. Great Bahama Bank.
D. South Bight, Andros Island.
E. West side of Andros Island.
F. From 825 fathoms depth.
G. From 800 to 820 fathoms.
H. Calcareous sand, Nassau.
I. Oolite, New Providence Island.

	C	D	E	F	G	H	I
Insoluble	0.13	0.46	0.89	1.05	1.34	0.04	0.02
MgO	.18	1.16	5.82	1.85	1.30	.36	Trace.
CaO	53.98	51.75	43.47	51.30	51.05	54.47	55.11
CO_2	42.42	42.92	40.49	42.31	41.52	43.17	43.30
	96.71	96.29	90.67	96.51	95.21	98.04	98.43

ANALYSES OF SLATES AND SHALES.

VERMONT.

Samples A to I, inclusive, are described by T. Nelson Dale in 19th Ann., pt. 3. Analyses by W. F. Hillebrand, record Nos. 1567, 1656. Roofing slates of Cambrian age.

A. McCarty quarry, South Poultney.
B. Unfading green, Eureka quarry, Poultney.
C. Sea green, Griffith and Nathaniel quarry, South Poultney.
D. Sea green, Rising and Nelson's quarry, Pawlet.
E. Sea green, Brownell quarry, Pawlet.
F. Black, American Black Slate Co., Benson.

	A	B	C	D	E	F
SiO_2	61.63	59.27	62.37	67.76	59.84	59.70
Al_2O_3	16.33	18.81	15.43	14.12	15.02	16.98
Fe_2O_3	4.10	1.12	1.34	.81	1.23	.52
FeO	2.71	6.58	5.34	4.71	4.73	4.88
MgO	2.92	2.21	3.14	2.38	3.41	3.23
CaO	.50	.42	.77	.63	2.20	1.27
Na_2O	1.26	1.88	1.14	1.39	1.12	1.35
K_2O	5.54	3.75	4.20	3.52	4.48	3.77
H_2O-	.31	.32	.34	.23	.41	.30
H_2O+	3.24	3.98	3.71	2.98	3.44	3.82
TiO_2	.68	.99	.74	.71	.74	.79
P_2O_5	.16	.11	.06	.07	.09	.16
MnO	.09	.13	.22	.10	.34	.16
BaO	.06	.05	.07	.04	.09	.08
CO_2	.41	.21	.87	.40	2.98	1.40
FeS_2	.04	.15	.06	.22	.05	1.18
C	None.	None.	Trace.	None.	Trace?	.46
	99.98	99.98	99.80	100.07	100.17	100.05

All six contain traces of lithia, of sulphates, and of nickel or cobalt.

G. Unfading green, Valley Slate Co.'s quarry, Poultney.
H. Mottled, purple and green, Eureka quarry, Poultney.
I. Purple, 1 mile south of Hydeville, in Castleton.

	G	H	I
SiO_2	59.48	60.24	60.96
Al_2O_3	18.22	18.46	16.15
Fe_2O_3	1.24	2.56	5.16
FeO	6.81	5.18	2.54
MgO	2.50	2.33	3.06
CaO	.56	.33	.71
Na_2O	1.55	1.57	1.50
K_2O	3.81	4.09	5.01
H_2O-	.17	.18	.17
H_2O+	4.05	3.81	3.08
TiO_2	1.02	.92	.86
P_2O_5	.10	.11	.23
MnO	.07	.07	.07
BaO	.05	.03	.04
CO_2	.39	.08	.68
FeS_2	.13	.16	None.
F	.08	Undet.	Undet.
N, as NH_3	.03	.03	.01
	100.26	100.15	100.28

[illegible] contain traces of lithia, nickel, and chlorine, and possibly of zirconia; in G and H traces of stron[illegible] in I.

J. Slate from Guilford, collected for the educational series of rock specimens. Analysis by L. G. Eakins, record No. 1316.

K. Slate from the Lakeshore quarry, Hydeville. Analysis by Eakins, record No. 1159.

	J	K
SiO_2	60.72	58.15
Al_2O_3	22.59	18.93
Fe_2O_3		2.91
FeO	6.03	5.64
MgO	2.05	2.70
CaO	.41	.60
Na_2O	.86	1.17
K_2O	3.69	3.92
H_2O	3.01	4.56
TiO_2		.93
P_2O_5	.13	.12
MnO	Trace.	.07
SO_3		.16
C	.57	
	100.06	99.86

NEW YORK.

Roofing slates from Washington County, collected by T. Nelson Dale. Of Cambrian age. Described by Dale in 19th Ann., pt. 3.

A. Red, three-fourths mile south of Hampton Village.

B. Empire Red Slate Co., near Granville.

C. National Red Slate Co., Granville.

D. Green, three-fourths mile northwest of Janesville.

Analyses by W. F. Hillebrand, record No. 1567.

	A	B	C	D
SiO_2	67.61	67.55	56.49	67.89
Al_2O_3	13.20	12.59	11.59	11.03
Fe_2O_3	5.36	5.61	3.48	1.47
FeO	1.20	1.24	1.42	3.81
MgO	3.20	3.27	6.43	4.57
CaO	.11	.26	5.11	1.43
Na_2O	.67	.61	.52	.77
K_2O	4.45	4.13	3.77	2.82
H_2O-	.45	.40	.37	.36
H_2O+	2.97	3.03	2.82	3.21
TiO_2	.56	.58	.48	.49
P_2O_5	.05	.10	.09	.10
MnO	.10	.19	.30	.16
BaO	.04	.31	.06	.04
CO_2	None.	.11	7.42	1.89
FeS_2	.03	.04	.03	.04
	100.00	100.02	100.38	100.08

All contain traces of lithia, of sulphates, and of nickel or cobalt. No carbonaceous matter is present.

E. Red slate from quarry 3 miles north of Raceville.

F. Green spot in E.

G. Purple rim of green spot F.

Analyses by W. F. Hillebrand, record No. 1656.

	E	F	G
SiO_2	63.88	65.44	64.59
Al_2O_3	9.77	9.38	10.23
Fe_2O_3	3.86	1.09	1.79
FeO	1.44	1.06	1.19
MgO	5.37	4.92	5.12
CaO	3.53	4.53	4.07
Na_2O	.20	.22	.23
K_2O	3.45	3.57	3.70
H_2O-	.27	.25	.28
H_2O+	2.48	2.10	2.29
TiO_2	.47	.52	.51
P_2O_5	.08	.08	.08
MnO	.21	.32	.26
BaO	.05	.06	.05
CO_2	5.08	6.55	5.84
FeS_2	Trace.	.04	Trace.
	100.14	100.13	100.23

Contain trace of lithia and nickel. Fluorine not determined.

PENNSYLVANIA.

Slates from Lehigh and Berks counties, collected by T. Nelson Dale. Analyses by W. F. Hillebrand, record No. 2015. Rocks A, B, described in Bull. 275, p. 84.

A. Black roofing slate, Washington vein, Hazel Dell quarry, north of Slatington. Sp. gr., 2.780, 21°.

B. Black roofing slate, lower Franklin vein, old Franklin quarry, Slatington. Sp. gr., 2.783, 21°.

C. Black roofing slate, partly weathered, 1½ miles northwest of Waxatawny, Berks County. Dark variety.

D. Like C, light variety.

E. Weathered slate or "shale clay," one-half mile south of Fogelsville.

F. Like E, one-fourth mile from Guth station, South Whitehall.

	A	B	C	D	E	F
SiO_2	56.85	56.38	65.56	68.81	64.50	75.77
Al_2O_3	15.24	15.27	17.06	16.44	21.67	15.30
Fe_2O_3	5.52	1.67	4.19	3.14	1.83	
FeO		3.23				
MgO	2.93	2.84	1.31	1.00	1.09	.81
CaO	4.24	4.23	.20	.20	.18	.20
Na_2O	1.38	1.30	.26	.27	.20	Trace.
K_2O	3.34	3.51	3.81	4.32	4.26	2.85
H_2O-	.45	.77	7.09	5.33	5.65	4.69
H_2O+	Undet.	4.09				
TiO_2	.84	.78	.68	.77	.85	.36
ZrO_2		Trace?				
CO_2	3.58	3.67	None.	None.		
P_2O_5	Undet.	.17	Undet.	Undet.	Undet.	Undet.
S			.02			
Cr_2O_3	Trace?	Trace?				
MnO	Undet.	.09				
BaO	Undet.	.08				
SrO	Undet.	Trace.				
Li_2O	Undet.	Trace.				
FeS_2	1.72	1.72				
Carbonaceous matter	Undet.	.59	Undet.	Undet.		
	96.09	100.39	100.18	100.28	100.23	99.98

KENTUCKY, GEORGIA, ALABAMA.

A. Indurated Carboniferous shale, in contact with the peridotite dike of Elliott County, Ky. Described by Diller in Bull. 38. Analysis by T. M. Chatard, record No. 351.

B. Fragment of shale included in the Elliott County dike. Analysis by Chatard, record No. 353.

C. Bituminous shale, Dry Gap, Ga. Analysis by L. G. Eakins, record No. 1316. P. R. C. 22. Described by Diller in Bull. 150, p. 90.

D. Middle Cambrian shale, Coosa Valley, near Blaine, Cherokee County, Ala. Analysis by H. N. Stokes, record No. 1549.

	A	B	C	D
SiO_2	41.32	35.53	51.03	55.02
Al_2O_3	20.71	18.23	13.47	21.02
Fe_2O_3	2.59	2.46	8.06	5.00
FeO	5.46	4.81	....	1.54
MgO	1.91	2.01	1.15	2.32
CaO	9.91	21.17	.78	1.60
Na_2O	7.19	2.53	.41	.81
K_2O	.88	1.08	3.16	3.19
H_2O-	....	1.40	.81	2.44
H_2O+	8.78	9.00		5.65
TiO_2	.48	.95	....	.65
P_2O_5	.08	.08	.31	.06
MnO	.17	.13	....	Trace.
BaO	....	....	....	.04
SrO	....	....	....	Trace.
Li_2O	....	....	....	.03
SO_3	....	....	....	.02
S	....	....	7.29	....
Cl	....	....	....	Trace.
CO_2	.55	.88	....	.83
Carbonaceous matter	....	....	....	.32
Fixed carbon	....	....	13.11	....
Volatile hydrocarbons	....	....	3.32	....
	100.03	100.26	102.90	100.54
Less O=S	....	....	2.74	
			100.16	

OHIO.

Three samples of Utica shale from New Vienna. Collected by Edward Orton. Partial analyses by F. W. Clarke and R. B. Riggs, record No. 731.

	A	B	C
Insoluble	60.17	29.51	25.80
CaO	17.11	33.43	35.27
MgO	1.25	2.16	1.32
CO_2	15.24	27.16	27.40
	93.77	92.26	89.79

Iron and alumina are present in the soluble portions of these shales, the solvent being dilute hydrochloric acid.

MICHIGAN.

A. Clay slate, sec. 17, T. 43 N., R. 31 W., near Mansfield. Contains principally quartz, white mica, actinolite, rutile, hematite, and carbonaceous matter. Described by J. M. Clements in Mon. XXXVI, pp. 59, 61, 210. Analysis by George Steiger, record No. 1709.

B. Pink slate, from near base of Upper Huronian, Menominee district. Center of sec. 5, T. 39 N., R. 29 W., near Norway mine. Described by Bayley in Mon. XLVI, p. 298.

C. "Briar slate," Vulcan iron formation, Menominee district. Also described by Bayley, op. cit., p. 330.

Analyses B and C by E. T. Allen, record Nos. 1974, 1994.

	A	B	C
SiO_2	60.28	67.04	50.15
Al_2O_3	22.61	15.01	6.55
Fe_2O_3	2.53	3.54	33.80
FeO	.45	3.18	.94
MgO	1.35	2.11	.94
CaO	.13	.19	.16
Na_2O	.54	.29	.31
K_2O	5.73	4.00	4.38
H_2O-	.60	.67	.81
H_2O+	3.62	3.73	1.43
TiO_2	.69	.69	.52
P_2O_5	.03	.03	.08
S	....	.02	Trace.
Cr_2O_3	....	Trace.	Trace.
MnO	Trace.	Trace.	None.
BaO	.04	Trace.	None.
C	.97	....	....
	99.57	100.50	100.07

WISCONSIN.

Slates of the Penokee-Gogebic series, collected by C. R. Van Hise. A and C are described in Mon. XIX, p. 306, as magnetitic clay slates. Analyses by L. G. Eakins, record No. 392.

A. Sec. 6, T. 45 N., R. 2 E.
B. Sec. 1, T. 45 N., R. 1 E.
C. Sec. 4, T. 44 N., R. 2 W.

	A	B	C
SiO_2	53.44	59.73	52.58
Al_2O_3	19.62	22.78	20.76
Fe_2O_3	11.38	.11	12.17
FeO	5.35	5.98	4.08
MgO	1.58	2.94	1.33
CaO	.42	.53	.30
Na_2O	2.61	1.41	.37
K_2O	1.73	3.48	4.87
H_2O	4.07	3.28	3.43
P_2O_5	Trace.	....	....
MnO	Trace.	.09	.21
Li_2O	Trace.	....	Trace.
	100.20	100.33	100.10

MINNESOTA.

Slates from the Mesabi district, described by C. K. Leith in Mon. XLIII. Analyses by George Steiger, record Nos. 1931, 1992.

A. Typical "Virginia slate." Average sample. About half chlorite, with quartz and perhaps some feldspar fragments.

B. Siliceous slate, from contact with gabbro, north of Birch Lake.

C. Slaty phase of the iron formation, Moss mine.

	A	B	C
SiO_2	62.26	78.95	37.11
Al_2O_3	16.89	None.	2.41
Fe_2O_3	1.76	13.89	17.51
FeO	4.55	1.23	26.13
MgO	2.95	.18	3.70
CaO	.42	.81	.75
Na_2O	2.29	None.	.09
K_2O	3.02	None.	.62
H_2O-	.70	.73	.95
H_2O+	3.88	2.21	2.57
TiO_2	.60	None.	.22
CO_2	None.	1.59	6.16
P_2O_5	.20	.04	.09
MnO		.11	1.21
C (organic)	Present.		.73
	99.52	99.74	100.25

WYOMING AND MONTANA.

A, B. Calcareous shales, Bull Lake Canyon, Wind River Mountains, Wyo. Collected by E. Blackwelder. Analyses by J. G. Fairchild, record No. 2530.

C. Wolsey shale, east side Cable Mountain, Philipsburg quadrangle, Montana. Collected by F. C. Calkins. Analyses by W. T. Schaller, No. 2498.

	A	B	C
SiO_2	17.80	37.91	53.29
Al_2O_3	5.78	7.00	22.38
Fe_2O_3	4.78	1.03	6.57
FeO	.42	.47	
MgO	14.97	12.35	2.10
CaO	19.58	13.28	.53
Na_2O	1.28	1.19	1.11
K_2O	1.96	2.00	7.43
H_2O-	.52	.53	4.12
H_2O+	.55	1.14	
TiO_2			.91
CO_2	31.96	23.22	.58
Cl	Trace.	Trace.	
	99.60	100.12	99.02

COLORADO.

Shales from the Pueblo quadrangle, collected by G. K. Gilbert.

A, B. Near Nushbaum Spring.

C. Salt Creek.

D. Head of Rock Creek.

E. Near Rush Creek.

Analyses by George Steiger, record No. 1466.

	A	B	C	D	E
SiO_2	60.80	51.69	60.60	63.60	45.89
Al_2O_3	15.63	16.50	16.42	16.74	13.24
Fe_2O_3	4.62	7.90	4.95	4.63	3.88
MgO	2.73	2.10	1.43	1.19	2.12
CaO	1.63	4.41	1.61	.68	12.09
Na_2O	1.45	2.07	.92	.29	.47
K_2O	2.55	2.68	2.98	2.92	2.31
H_2O-	3.19	3.02	3.91	2.88	1.38
H_2O+	4.16	6.00	5.72	5.99	4.16
TiO_2	.47	.66	.35	.66	.52
P_2O_5	.10	.22	.31	.16	.17
CO_2		3.19			10.38
Organic matter	2.87	.53	.84	.46	3.47
	100.20	100.97	100.04	100.20	100.08

Calcareous shales from Fairplay, Park County. Partial analyses, by W. F. Hillebrand, made in the Denver laboratory.

	F	G
Insoluble	68.72	35.14
Fe_2O_3, Al_2O_3, etc	2.10	....
FeO, MnO	....	2.10
MgO	5.72	12.55
CaO	9.06	19.34
H_2O	1.01	.73
CO_2, calculated	13.41	30.28
	100.02	100.14

NEW MEXICO.

Shales from Hermosa. Collected by C. H. Gordon. Analyses by G. Steiger, record No. 2239.

	A	B
SiO_2	34.64	49.13
Al_2O_3	25.58	13.92
Fe_2O_3	.35	.77
FeO	3.60	1.87
gO	17.47	5.11
CaO	.75	8.73
Na_2O	.26	.20
K_2O	None.	4.25
H_2O-	3.67	1.52
H_2O+	10.38	4.69
TiO_2	.83	.66
CO_2	None.	6.93
P_2O_5	.06	.03
MnO	.48	.25
FeS_2	1.70	.86
C	....	2.00
	99.77	100.92

ZrO_2, SrO, BaO absent.

ARIZONA.

Shales from the Morenci district, collected by W. Lindgren. Analyses by W. F. Hillebrand, record No. 1997. Described in P. P. 43, p. 130.

A. Fresh, black, Devonian shale, near Longfellow mine.

B. Same locality, adjoining dike. The result of contact metamorphism.

	A	B
SiO_2	61.25	60.51
Al_2O_3	15.60	15.81
Fe_2O_3	1.35	1.40
FeO	3.04	2.64
MgO	4.16	4.25
CaO	3.40	2.34
Na_2O	.44	1.26
K_2O	6.74	8.27
H_2O-	.62	.59
H_2O+	2.09	1.90
TiO_2	.66	.68
ZrO_2	Trace?	Trace.
P_2O_5	.08	.08
MnO	.07	.11
BaO	Trace.	.17
SrO	None.	.01
Li_2O	Trace.	Trace.
FeS_2	.25	.04
$CuFeS_2$	.03	Trace.
ZnO	.03	.02
	99.81	100.08

CO_2 and SO_2 are both absent.

CALIFORNIA.

Cretaceous shales from Mount Diablo. Described by Turner and Melville, Bull. Geol. Soc. America, vol. 2, pp. 383–414. Analyses by W. H. Melville, made in the laboratory at San Francisco, except F (record No. 1166), which was made in the Washington laboratory.

A. Brownish black, resinous. From Bagley Canyon.

B. Slate colored, soft, friable, little altered. From near Bagley Creek.

C. Same locality as B, less friable, but considerably altered.

D. Slate colored, friable. From Arroyo del Cerro.

E. Very friable. Same locality as D.

	A	B	C	D	E
SiO_2	56.66	53.65	49.14	25.05	40.17
Al_2O_3	17.64	17.64	16.91	8.28	12.76
Fe_2O_3	.49	4.06	4.39	.27	2.10
FeO	5.22	3.72	3.82	2.41	3.56
MgO	3.50	5.15	5.43	2.61	15.42
CaO	1.67	2.27	3.28	27.87	4.24
Na_2O	2.17	2.53	4.67	Undet.	.57
K_2O	2.27	2.22	1.53	Undet	1.36
H_2O-	3.01	3.95	3.39	1.44	9.19
H_2O+	5.92	4.57	6.97	2.86	6.73
P_2O_5	.15	.23	.24	.08	.08
NiO		Trace.	Trace.	Trace.	Trace.
MnO	.19	.01	.22	4.11	.16
CO_2				24.20	3.48
SO_3	.93				
	99.82	100.00	99.99	99.18	99.82

F. Neocomian shale, altered, light brown, friable. From near Arroyo del Cerro.

G. Calcareous shale, near Arroyo del Cerro. Hard, compact, dark colored. Very much altered.

H. Red shale, metamorphic area at head of Bagley Creek.

I. Silicified shale or phthanite, same locality as H.

J. Clay slate, near the head of Yaqui Gulch, in Mariposa County. Described by Turner in Bull. 150, p. 342. Contains grains of quartz and feldspar, abundant carbonaceous particles, a chloritic substance (?), and a fibrous alteration of sillimanite (?). Analysis by George Steiger, record No. 1643.

	F	G	H	I	J
SiO_2	45.64	44.56	69.98	93.54	60.35
Al_2O_3	15.42	3.12	11.69	2.26	17.62
Fe_2O_3	3.40	1.27	6.23	.48	5.64
FeO	3.73	5.21	1.08	.79	2.20
MgO	4.62	3.39	1.29	.66	1.04
CaO	8.11	12.70	.38	.09	.45
Na_2O	3.13	3.09	.73	.37	1.00
K_2O	1.86	.88	3.72	.51	3.16
H_2O-	8.74	1.41	1.03	.21	1.02
H_2O+		6.24	2.92	.72	4.36
TiO_2					.75
P_2O_5	.27	.16	.05		.17
Cr_2O_3	.12				
MnO	.33	Trace.	.49	.23	None.
BaO					.12
CO_2	4.59	17.62			None.
SO_3					.05
Cl					.01
F					Trace.
C					1.72
	99.96	99.65	99.59	99.86	99.76

BRITISH COLUMBIA.

Cambrian slate, from a ridge between Mount Field and Mount Wapta, near Field. Collected by C. D. Walcott. Analysis by G. Steiger, record No. 2615.

SiO_2	54.49	TiO_2	0.72
Al_2O_3	25.60	CO_2	1.54
Fe_2O_3	.89	P_2O_5	.08
FeO	2.00	S	.24
MgO	1.18		
CaO	1.90		99.83
Na_2O	.28	Less O	.09
K_2O	6.67		
H_2O-	.33		99.74
H_2O+	3.91		

MnO, BaO, SrO absent.

ANALYSES OF CLAYS, SOILS, ETC.

MAINE.

A, B, two clays from Thomaston, collected by Edson S. Bastin. Analyses by W. T. Schaller, record No. 2230.

A. Thomaston brick yard.

B. Haydens Point.

C. Marine clay, Portland quadrangle. Collected by F. J. Katz. Analysis by Steiger, No. 2733.

	A	B	C
SiO_2	62.80	62.33	61.72
Al_2O_3	17.36	17.70	18.02
Fe_2O_3	4.40	5.19	5.38
FeO	[a]2.00	[a]1.72	
MgO	.88	1.00	1.77
CaO	1.58	1.53	1.92
Na_2O	1.48	2.38	2.66
K_2O	3.05	2.41	4.50
H_2O-	1.31	1.11	3.36
H_2O, ignition	4.30	3.81	
TiO_2	.87	.79	.79
	100.12	99.97	100.12

[a] Uncertain because of organic matter in the clays, which is included under "ignition."

CO_2 absent, P_2O_5 undetermined.

MASSACHUSETTS.

Two glacial clays collected by W. C. Alden. Analyses by G. Steiger, record No. 2308.

A. Lancaster. B. Still River.

	A	B
SiO_2	66.65	57.88
Al_2O_3	16.93	20.68
Fe_2O_3	3.05	3.94
FeO	.84	2.08
MgO	.96	1.60
CaO	1.07	1.03
Na_2O	2.05	1.99
K_2O	3.60	4.74
H_2O-	1.54	1.38
H_2O+	3.03	3.63
TiO_2	.80	.88
	100.52	99.83

The following clays and soils from Marthas Vineyard were collected by N. S. Shaler. See 7th Ann., p. 303. Analyses by F. W. Clarke, record Nos. 439, 440, 441, 442, 443, 444, 445, 446, 454, and 455. Partial analyses only.

A. Average sample of white clay, east end of Chilmark Cliffs.

B. Average sample of clays, Weyquosque series, Chilmark Cliffs.

C. Average sample of fine clay and soil, east end of Weyquosque Cliffs

D. Sandy white clay, south end of Gay Head Cliffs.

E. Average sample of fine white clay, south end of Gay Head Cliffs.

F. Average sample of clay, north end of Gay Head Cliffs.

G. Average sample of southernmost red clays, Gay Head.

H. Brown clay, south of light-house, Gay Head Cliffs.

I. Average sample of red clay from the greensand, north end of Gay Head.

J. Pyritiferous clay, central part of Gay Head section.

	A	B	C	D	E	F	G	H	I	J
SiO_2	82.95	61.76	70.81	56.19	73.46	49.19	57.50	56.62	55.93	72.74
Al_2O_3, Fe_2O_3	13.45	25.35	20.67	30.65	19.06	39.77	31.21	31.24	33.51	21.46
MgO	Trace.	1.95	1.99	Trace.	Trace.	Trace.	.20	1.97	.19	Trace.
CaO	None.	.51	Trace.	None.	None.	None.	.19	Trace.	None.	None.
Na_2O	....	1.83	1.23	....	.70	....	.40	.40	Undet.	....
K_2O	....	3.01	1.67	....	.73	....		2.76	Undet.	....
Ignition	3.47	5.76	3.39	10.79	6.36	11.47	9.83	7.57	9.98	5.69
P_2O_5	None.	Trace.	None.	None.	None.	None.	None.	None.	None.	None.
SO_3	....	....	....	2.45	None.	....	....	....	....	....
	99.87	100.17	99.76	100.08	100.31	100.43	99.33	100.56	99.61	99.89

CONNECTICUT.

Five brick clays, received from H. E. Gregory. Analyses by W. T. Schaller, record No. 2138.

A. East Windsor Hill Brick Co., South Windsor.
B. Park Brick Co., West Hartford.
C. Berlin Brick Co., Berlin.
D. Tuttle Brick Co., Newfield.
E. I. L. Stiles & Son, New Haven.

	A	B	C	D	E
SiO_2	52.73	50.33	58.02	55.27	56.75
Al_2O_3	22.25	27.06	17.93	20.52	17.54
Fe_2O_3	4.55	2.29	4.89	5.34	4.92
FeO	3.14	2.62	1.24	1.55	.93
CaO	1.48	1.22	3.42	2.21	4.18
MgO	3.20	3.34	1.92	2.80	2.34
Na_2O	2.22	1.78	3.33	2.82	3.40
K_2O	4.28	4.40	3.06	3.43	3.16
H_2O-	1.12	1.42	.99	1.37	1.24
H_2O, ignition	4.91	5.24	5.36	5.06	6.28
	99.88	99.70	100.16	100.37	100.74

TiO_2, P_2O_5, etc., not looked for.

NEW YORK, PENNSYLVANIA.

A. Clay, near Richfield Springs, New York. Partial analysis by Charles Catlett, record No. 946.

B, C. Clays, Northumberland County, Pa. Analyses by Charles Catlett, record No. 952.

D. White clay, derived from sericite schist, South Mountain. Pa. Collected by G. W. Stose. Analysis by W. T. Schaller, record No. 2302.

	A	B	C	D
SiO_2	49.65	65.97	59.16	69.61
Al_2O_3	23.82	20.37	18.68	16.83
Fe_2O_3		2.75	10.32	.95
MgO	Trace.	.52	.67	1.51
CaO	6.48	.64	.52	.11
Na_2O	Undet.	.05	.11	.08
K_2O	Undet.	3.32	3.35	3.41
H_2O-	16.18	6.28	6.87	6.35
H_2O+				
TiO_2	....	....	....	.90
P_2O_5	....	....	....	.14
	96.13	99.90	99.68	99.89

E to H. Fire clays from Johnstown quadrangle, Pennsylvania. Collected by W. C. Phalen. Partial analyses by E. C. Sullivan, record No. 2281.

	E	F	G	H
SiO_2	65.9	66.4	50.3	53.1
Al_2O_3	20.3	19.8	21.3	27.8
Fe_2O_3[a]	1.60	1.68	10.4	3.08
MgO	.66	.61	.61	.60
CaO	.09	.10	.39	.22
Na_2O	.34	.30	.18	.48
K_2O	2.98	3.24	1.14	3.58
TiO_2	1.2	1.0	.9	1.2
Ignition	6.5	6.4	12.0	10.2
	99.57	99.53	97.22	100.26

[a] Total iron.

MARYLAND.

Clays from the Matawan formation, received from W. B. Clark. Analyses by George Steiger, record No. 1684.

A. Below Barnard's wharf, near Betterton, Kent County.
B. Severn River, below Round Bay, Anne Arundel County.
C. Magothy River, near Wilson's wharf, Anne Arundel County.
D. Fort Washington Bluff.

	A	B	C	D
SiO_2	73.47	87.15	82.86	73.02
Al_2O_3[a]	12.69	6.46	6.49	10.00
Fe_2O_3	4.62	2.15	3.54	4.78
MgO	.59	.27	.52	.90
CaO	.15	.10	.29	.57
Na_2O	.09	.14	.16	.59
K_2O	1.55	.90	1.16	1.92
H_2O-	.89	.32	.69	1.09
H_2O+	3.85	1.90	2.24	3.07
SO_3	.19	None.	.21	1.04
	98.09	99.39	98.16	96.98

[a] Titanic and phosphoric oxides not separated.

No carbonates present. Sulphides undetermined.

VIRGINIA AND NORTH CAROLINA.

A. Residual clay from decay of Trenton limestone, Lexington, Va. Described by Russell in Bull. 52. Analysis by R. B. Riggs, record No. 373. See also analysis of the limestone.

B. Residual clay from limestone, Staunton, Va.

C. Portion of B soluble in weak hydrochloric acid.

D. Insoluble portion of B. Analyses B, C, and D by George Steiger, record No. 1630. See also analysis of limestone.

E. Decomposed dolerite, near Wadesboro, N. C. Described by Russell in Bull. 52. Analysis by T. M. Chatard, record No. 327.

F. Residual clay from decay of chloritic schist, Cary, 8 miles west of Raleigh, N. C. Analysis by R. B. Riggs, record No. 364. Described by Russell in Bull. 52.

	A	B	C	D	E	F
SiO_2	43.07	55.90	3.09	52.81	39.55	54.54
Al_2O_3	25.07	19.92	3.96	15.96	28.76	26.43
Fe_2O_3	15.16	7.30	6.25	1.05	16.80	9.04
FeO		.39	.30	.09		
MgO	.03	1.18	.43	.75	.59	
CaO	.63	.50	.30	.20	.37	
Na_2O	1.20	.23	.20	.03	Undet.	
K_2O	2.50	4.79	.28	4.51	Undet.	
H_2O-	12.98	2.54			13.26	9.87
H_2O+		6.52	2.10	4.42		
TiO_2		.20	.04	.16	.64	
P_2O_5		.10	.04	.06	.10	
Cr_2O_3					Trace.	
MnO		None.			Trace.	
CO_2		.38	.38	None.		
	100.64	99.95	17.37	80.04	100.07	99.88

SOUTH CAROLINA AND GEORGIA.

A. Clay from Charleston, S. C. Received from E. C. Eckel. Analysis by W. F. Hillebrand, record No. 2187.

B, C, D. Clays from near Augusta, Ga. Partial analyses by G. Steiger, record No. 1395.

	A	B	C	D
SiO_2	50.12	60.24	61.36	60.70
Al_2O_3	18.04	26.72	29.04	29.24
Fe_2O_3	5.91			
CaO	6.14	.88	.76	.68
MgO	.48	Present.	Present.	Present.
Na_2O	.22	Undet.	Undet.	Undet.
K_2O	.46	Undet.	Undet.	Undet.
H_2O	13.91	6.28	7.46	6.74
CO_2	3.73			
P_2O_5	.07			
SO_3	.09			
TiO_2	.99			
MnO	(?)			
	100.16	94.12	98.62	97.36

FLORIDA.

A. Hammock clay, Melborne Creek. Collected by N. S. Shaler. Partial analyses by L. G. Eakins, record No. 881.

B. Clay, Tampa.

C. Clay, Lakeland.

	A	B	C
SiO_2	38.04	70.78	80.39
Al_2O_3, Fe_2O_3	27.19	11.33	15.03
MgO	.46		
CaO	10.73	2.18	1.22
H_2O	[a] 23.61	14.55	4.34
	100.03	98.84	100.98

[a] Includes some CO_2.

Clays collected by G. H. Eldridge.

D, E. From the Sandlin place, 2 miles southeast of Marion, Hamilton County.

F. From Richmond's, 6 miles south of Leesburg, Lake County.

G, H. From Bartow Junction.

Analyses D, E, and F by H. N. Stokes, record No. 1493; G and H by George Steiger, No. 1545.

	D	E	F	G	H
SiO_2	15.68	78.23	84.41	79.99	79.48
Al_2O_3	.61	7.30	11.02	10.82	12.14
Fe_2O_3	.45	1.85	Trace.	3.25	2.64
FeO				.25	.09
MgO	17.28	2.11	Trace.	.07	.07
CaO	26.11	1.60	.20	.23	.31
H_2O-	1.97	[a] 8.48	[a] 4.25	.90	.86
H_2O+				4.09	4.73
P_2O_5	Trace.	Trace.	Trace.		
CO_2	37.90			None.	None.
	100.00	99.57	99.88	99.87	100.32

[a] Includes a little CO_2.

I. "Filtering clay," Ocala. Received from D. T. Day. Analysis by H. N. Stokes, record No. 1738.

SiO_2	36.73
Al_2O_3	27.78
Fe_2O_3	3.21
MgO	.64
CaO	.81
Na_2O	None.
K_2O	.42
H_2O-	7.38
H_2O+	12.14
TiO_2	1.27
P_2O_5	5.54
CO_2	None.
Organic matter	3.61
	99.53

ALABAMA AND MISSISSIPPI.

A. Kaolin, Greenville, Ala. Contains about 40 per cent of kaolinite, with fragments of quartz, feldspar, and mica. Analysis by T. M. Chatard, record No. 1148.

B. Residual clay, from decay of Knox dolomite, Morrisville, Ala. Described by Russell in Bull. 52. Analysis by W. F. Hillebrand, record No. 797. See also analysis of the dolomite.

C. Clay, from brown iron ore mine, Reno, Ala. Collected by E. F. Burchard. Analysis by R. C. Wells, record No. 2397.

D. Loess, from Vicksburg, Miss. Described by Chamberlin and Salisbury, 6th Ann., p. 282. Analysis by R. B. Riggs, record No. 294.

E. Stoneware clay, Holly Springs, Miss. Analysis by E. C. Sullivan, record No. 2105. Alkalies not separated, calculated as K_2O.

F. Clay, Scooba, Miss. Partial analysis by H. C. McNeil, record No. 2181.

	A	B	C	D	E	F
SiO_2	69.84	55.42	63.00	60.69	64.77	61.92
Al_2O_3	19.91	22.17	13.11	7.95	22.07	19.47
Fe_2O_3	.90	8.30	3.04	2.61	1.55	2.81
FeO		Trace.		.67		
MgO	.28	1.45	.18	4.56	.33	1.98
CaO	.07	.15	.23	8.96	.09	None.
Na_2O	.21	.17	.31	1.17	1.36	.50
K_2O	2.14	2.32	7.46	1.08		None.
H_2O-	.06	2.10	2.95			
H_2O+	6.72	7.76	3.91	1.14	8.69	12.29
TiO_2			.44	.52	1.13	
CO_2			None.	9.63		
P_2O_5			None.	.13		
SO_3			3.81	.12	Trace.	
Cl				.08		
C, organic			Trace.	.19		
MnO	Trace.		1.10	.12		
	100.13	99.84	99.54	99.62	99.99	98.97

LOUISIANA.

Composite analysis of 235 samples of river silt, from the Delta of the Mississippi. Received from C. E. Siebenthal. Collected by E. W. Shaw. Analysis by G. Steiger, record No. 2840.

SiO_2	69.96	S	0.07
Al_2O_3	10.52	Cr_2O_3	.01
Fe_2O_3	3.47	V_2O_3	.02
FeO		NiO	.017
MgO	1.41	MnO	.06
CaO	2.17	BaO	.08
Na_2O	1.51	SrO	Trace.
K_2O	2.30	CuO	.0043
H_2O-	3.78	ZnO	.0010
H_2O+	1.96	As_2O_5	.0004
TiO_2	.59	PbO	.0002
ZrO_2	.05	Organic matter	.66
CO_2	1.40		
P_2O_5	.18		100.6229
SO_3	.03	Less O	.12
Cl	.30		
F	.07		100.5029

KENTUCKY AND TENNESSEE.

A. Fire clay, Carter County, Ky. Analysis by F. W. Clarke, record No. 2073.

B. Black clay, Mandle's pit, Paris, Tenn.

C. Ball clay, same locality as B.

Analyses B and C by E. C. Sullivan, record No. 2105.

D. Clay, east of Parsons, Tenn.

E. Clay, Robins & Henderson pit, Pinson, Tenn.

Analyses D and E by W. T. Schaller, record No. 2107. All analyses partial only.

	A	B	C	D	E
SiO_2	42.71	46.34	52.31	70.76	70.56
Al_2O_3	38.88	30.30	30.09	19.29	18.18
Fe_2O_3 (total Fe)	3.36	1.19	1.29	1.09	1.30
MgO	None.	.34	.38	.68	.55
CaO	.13	.24	.13	.14	.08
K_2O (total alkali	Undet.	.78	1.72	Undet.	Undet.
Ignition	15.19	19.68	12.44	6.02	8.13
TiO_2	Undet.	1.42	1.10	Undet.	Undet.
SO_3	....	Trace.	Trace.	Trace.	Trace.
	100.27	100.29	99.46	97.98	98.80

OHIO.

White clay, 1¼ miles north of Delhi. Received from N. M. Fenneman. Analysis by G. Steiger, record No. 2445.

SiO_2	61.12	H_2O-	3.88
Al_2O_3	14.28	H_2O+	3.89
Fe_2O_3	7.54	TiO_2	.85
FeO	.50	CO_2	None.
MgO	1.48	P_2O_5	.81
CaO	1.87		
Na_2O	.84		100.14
K_2O	3.08		

ILLINOIS, IOWA, MINNESOTA.

A, B. Clays from Henry County, Ill. Analyses by T. M. Chatard, record No. 144.

C. Loess, a stratum overlying residuary clay, 350 feet above Mississippi River, near Galena, Ill. Described by Chamberlin and Salisbury, 6th Ann., p. 282. Analysis by R. B. Riggs, record No. 293. Dried at 100°.

D. Loess, 300 feet above the Mississippi, 3½ miles northwest of Dubuque, Iowa. Described by Chamberlin and Salisbury (loc. cit.), and analyzed by Riggs, No. 292. Dried at 100°.

E. Tallow clay, lead mine at Lansing, Iowa. Collected by W. P. Jenney. Analysis by H. N. Stokes, record No. 1337. Dried at 100°. Partial analysis.

F. Greenish-gray clay, New Ulm, Minn. Analysis by T. M. Chatard, record No. 825.

	A	B	C	D	E	F
SiO_2	46.12	42.58	64.61	72.68	52.08	61.32
Al_2O_3	15.24	12.16	10.64	12.03	23.11	12.27
Fe_2O_3	4.41	3.90	2.61	3.53	9.34	3.62
FeO			.51	.96		4.18
MgO	3.63	4.32	3.69	1.11	2.12	1.76
CaO	8.63	11.33	5.41	1.59	1.04	.99
Na_2O	1.54	1.96	1.35	1.68	Undet.	.42
K_2O	3.79	3.88	2.06	2.13	Undet.	3.59
H_2O	15.57	18.64	2.05	2.50	9.80	10.73
TiO_2	.79	.64	.40	.72		.66
P_2O_5	.08	.10	.06	.23		.27
MnO	.28	.09	.05	.06		.27
ZnO					Trace.	
PbO					Trace.	
BaO						.05
CO_2			6.31	.39		
C, organic			.13	.09		
SO_3			.11	.51		.19
Cl			.07	.01		
	100.08	99.60	100.06	100.22	97.49	100.32

WISCONSIN.

Clays, etc.. described by Chamberlin and Salisbury in 6th Ann., pp. 250 and 282. Analyses by R. B. Riggs, record Nos. 259, 260, 261, 262, 290, 295. Dried at 100°.

A. Residuary clay from Dodgeville, 4½ feet below surface.

B. The same, 8½ feet below surface.

C. Residuary clay from near Cobb, 4½ feet below surface.

D. Same as C, 3½ feet below surface.

E. Red, putty-like clay, containing pebbles, Milwaukee.

F. Red pebble clay, Milwaukee.

	A	B	C	D	E	F
SiO_2	71.13	49.59	49.13	53.09	40.22	48.81
Al_2O_3	12.50	18.64	20.08	21.43	8.47	7.54
Fe_2O_3	5.52	17.19	11.04	8.53	2.83	2.53
FeO	.45	.27	.93	.86	.48	.65
MgO	.38	.73	1.92	1.43	7.80	7.05
CaO	.85	.93	1.22	.95	15.65	11.83
Na_2O	2.19	.80	1.33	1.45	.84	.92
K_2O	1.61	.93	1.60	.83	2.36	2.60
H_2O	4.63	10.46	11.72	10.79	1.95	2.02
TiO_2	.45	.28	.13	.16	.35	.45
P_2O_5	.02	.03	.04	.03	.05	.13
MnO	.04	.01	.06	.03	Trace.	.03
CO_2	.43	.30	.39	.29	18.76	15.47
C, organic	.19	.34	1.09	.22	.32	.38
SO_3					.13	.05
Cl					.06	.04
	100.39	100.50	100.68	100.09	100.27	100.50

G, H. Red glacial till. Oshkosh.

I. The same, buff color.

J. Red glacial till. New Haven Township, Adams County.

K. Glacial lacustrine clay, Delton Township, Sauk County. Samples G to K received from W. C. Alden. Analyses by W. T. Schaller, record No. 2457.

	G	H	I	J	K
SiO_2	43.20	56.58	41.84	42.76	40.56
Al_2O_3	11.42	14.22	7.90	12.28	14.91
Fe_2O_3 [a]	4.36	6.81	2.86	4.27	4.32
MgO	6.07	3.48	7.03	3.09	2.63
CaO	11.54	2.88	14.43	12.81	12.11
Na_2O	1.50	1.41	1.64	1.78	1.59
K_2O	2.46	3.44	1.46	2.48	2.57
H_2O	4.56	8.00	15.10	4.79	18.30
TiO_2	.59	.77	.49	.56	.57
CO_2	14.80	2.51	6.82	15.54	2.24
	100.50	100.10	99.57	100.36	99.80

[a] Total iron.

MISSOURI AND ARKANSAS.

A. Typical loess, Kansas City, Mo. Dried at 100°. Described by Chamberlin and Salisbury, 6th Ann., p. 282. Analysis by R. B. Riggs, record No. 291.

B, C, D, E. Tallow clays, Joplin, Mo. Collected by W. P. Jenney. Analyses by T. M. Chatard, record No. 1210.

F. Tallow clay, Aurora, Mo. Collected by Jenney. Analysis by Chatard, No. 1210. In analyses B, C, D, E, and F the percentages of bases relate to the portion soluble in hydrochloric acid. Analyses only partial.

	A	B	C	D	E	F
Insoluble	......	40.64	43.07	39.34	39.62	34.04
SiO_2	74.46	......	......	......	......	......
Al_2O_3	12.26	5.72	7.60	6.17	6.45	10.01
Fe_2O_3	3.25	1.30	1.12	1.16	1.53	3.62
FeO	.12	......	......	......	......	......
MgO	1.12	.27	.32	.27	.30	.25
CaO	1.69	1.80	1.70	2.13	1.77	2.09
Na_2O	1.43	......	......	......	......	......
K_2O	1.83	......	......	......	......	......
H_2O	2.70	17.19	16.74	17.63	16.95	16.96
TiO_2	.14	......	......	......	......	......
P_2O_5	.09	......	......	......	......	......
MnO	.02	......	......	......	......	......
ZnO	......	32.46	29.43	34.28	33.55	33.49
CO_2	.49	......	......	......	......	......
C, organic	.12	......	......	......	......	......
SO_3	.06	......	......	......	......	......
Cl	.05	......	......	......	......	......
	99.83	99.38	99.98	100.98	100.17	100.46

The following partial analyses by H. N. Stokes, record No. 1260, all relate to tallow clays collected by W. P. Jenney. The same remarks apply as to B, C, D, E, and F.

G. Cave Springs mine, Jasper County, Mo.

H. Great Western mine, Granby, Mo.

I, J, K. Woodcock mine, Granby, Mo.

L. Coon Hollow, Boone County, Ark.

Material dried at 103°.

	G	H	I	J	K	L
Insoluble	34.89	11.25	2.41	16.17	3.85	18.18
Soluble SiO_2	16.75	32.89	36.71	28.62	37.08	29.02
Al_2O_3	7.38	10.78	8.21	8.93	6.46	6.34
Fe_2O_3	10.34	3.89	2.75	5.98	3.49	4.40
ZnO	14.35	29.54	38.59	26.23	38.90	30.50
CaO	1.55	2.65	2.77	2.01	2.56	1.91
MgO	.35	.90	.78	.46	.42	.75
Ignition	10.37	8.22	7.99	9.19	7.52	8.36
	95.98	100.12	100.21	97.59	100.28	99.46

The following clays, M to R, from the Hot Springs district, Arkansas, were received through E. C. Eckel. Analyses by G. Steiger, record No. 2221.

	M	N	O	P	Q	R
SiO_2	72.06	74.55	73.96	70.31	70.29	73.07
Al_2O_3	15.31	13.68	14.54	17.27	16.74	16.40
Fe_2O_3	1.24	1.27	2.17	1.85	2.03	1.12
MgO	2.26	2.03	.49	.91	1.50	.64
CaO	.17	.20	.15	.23	.10	.25
Na_2O	.15	.10	.80	.26	.08	.26
K_2O	4.53	3.84	2.64	3.51	2.76	2.75
H_2O-	.48	.77	1.36	.88	1.12	.36
H_2O+	3.50	3.63	3.76	4.36	5.00	4.46
TiO_2	.95	.73	.34	1.00	.64	1.09
	100.65	100.80	100.21	100.58	100.26	100.40

SOUTH DAKOTA AND WYOMING.

A. Red clay, east of Newcastle, S. Dak.

B. Red clayey sandstone, east of Spearfish, S. Dak. Analyses A and B by George Steiger, record No. 1854.

C. Loess, Cheyenne, Wyo. Analysis by L. G. Eakins, record No. 1066.

D. Loess (?), western foothills of Teton Mountains, Wyoming. Partial analysis by W. C. Wheeler, No. 2706.

E. Bentonite, Bighorn Basin, Wyo. Collected by D. F. Hewett. Analysis by R. C. Wells, No. 2792.

	A	B	C	D	E
Sand, etc	....	....	....	....	3.50
SiO_2	56.20	58.32	67.10	72.04	63.20
Al_2O_3	11.50	8.59	10.26	12.37	12.90
Fe_2O_3	3.64	2.04	2.52	3.38	2.46
FeO	.65	.18	.31	....	....
MgO	4.23	3.65	1.24	1.22	2.09
CaO	5.83	8.45	5.88	1.21	.82
Na_2O	.98	.72	1.42	1.83	.66
K_2O	3.74	2.71	2.68	2.58	.26
H_2O-	1.61	.52	5.09	3.15	13.80
H_2O+	2.84	1.40			
TiO_2	.77	.48	....	....	.11
CO_2	5.72	12.08	3.67	Trace.	....
P_2O_5	.12	.05	.11	....	....
SO_3	2.26	.43	....	....	....
Cl	Trace.	Trace.	....	....	....
MnO	.10	.07	....	....	....
Soluble in water	....	....	....	....	.20
	100.19	99.69	100.28	97.78	100.00

COLORADO.

A. Loess, Denver.

B. Loess, Highland.

C. Concretion in loess, Wray.

A, B, and C collected by S. F. Emmons. Analyses by L. G. Eakins, record No. 1066.

D. Clay, Davis ranch, Pueblo quadrangle.

E. Clay, head of Rock Creek, Pueblo quadrangle.

D and E collected by G. K. Gilbert. Analyses by George Steiger, record No. 1457.

	A	B	C	D	E
SiO_2	69.27	60.97	70.63	63.52	76.56
Al_2O_3	13.51	15.67	10.43	24.72	8.30
Fe_2O_3	3.74	5.22	2.58	.43	.38
FeO	1.02	.35	.48		
MgO	1.09	1.60	1.13	.13	.24
CaO	2.29	2.77	4.64	.30	.12
Na_2O	1.70	.97	1.29	Trace.	Trace.
K_2O	3.14	2.28	2.50	Trace.	Trace.
H_2O-	4.19	9.83	3.77	1.58	1.26
H_2O+				8.41	4.40
TiO_2				.68	.60
P_2O_5	.45	.19	.20	Trace.	.06
MnO	Trace.	Trace.			
CO_2	Trace.	.31	2.50		
Organic matter				.40	8.31
	100.40	100.16	100.24	100.17	100.23

F. From Red Creek Canyon, southern part of Colorado Springs quadrangle.

G. From 2 miles southeast of F.

H. From near canyon.

I. Overlying H.

Collected as probable fire clays by G. K. Gilbert. Analyses by George Steiger, record No. 1578. Fe_2O_3 represents total iron. Al_2O_3 includes TiO_2. In I the ignition includes some CO_2, which is absent from the others.

	F	G	H	I
SiO_2	85.09	86.79	57.98	69.04
Al_2O_3	6.98	8.29	27.51	14.51
Fe_2O_3	1.10	.75	1.68	3.78
MgO	.27	.13	.32	.73
CaO	.21	.34	.42	1.24
Na_2O	None.	None.	.03	.08
K_2O	.13	.25	.56	.48
Ignition	6.37	3.78	11.80	10.50
P_2O_5	.06	.05	.06	.07
	100.21	100.38	100.36	100.43

J to R. Supposed fire clays collected in the area of the Apishapa sheet, by G. K. Gilbert. Analyses, partial, by H. N. Stokes, record No. 1503. Titanium present, alkalies undetermined. Analyses made on ignited material, reckoned as 100. The loss on ignition is separately stated below each analysis.

	J	K	L	M	N	O	P	Q	R
SiO_2	86.58	78.07	76.96	61.98	93.11	85.98	85.25	54.93	58.56
Al_2O_3	12.72	20.22	20.77	37.51	5.56	13.67	11.45	43.65	39.17
Fe_2O_3	.45	.89	1.11	.45	1.15	.41	2.24	.69	.55
MgO	.11	.26	.32	.09	.10		.21	.05	.45
CaO	.11		.71	.19	.32	.21	.26	.64	1.08
	98.97	99.44	99.87	100.22	100.24	100.27	99.41	99.96	99.81
Ignition	4.75	7.51	7.98	12.51	4.45	5.07	4.81	16.80	19.58

S. Loesslike alluvium, Golden, Jefferson County.

T. Fire clay, Golden, Jefferson County.

Analyses S and T made by W. F. Hillebrand in the Denver laboratory.

	S	T
SiO_2	72.31	50.35
Al_2O_3	12.66	34.44
Fe_2O_3	4.67	.75
MgO	.94	Trace.
CaO	1.15	....
Na_2O	2.47	.10
K_2O	3.75	.48
H_2O+organic matter	1.80	13.88
P_2O_5	.23	....
	99.98	100.00

IDAHO AND UTAH.

A. Adobe soil, Salt Lake City, Utah. Analysis by L. G. Eakins, record No. 996.

B. Lava soil, near Shoshone Falls, Idaho. Described by Russell in Bull. 199. Analysis by W. F. Hillebrand, record No. 1950.

	A	B
SiO_2	19.24	52.48
Al_2O_3	3.26	7.10
Fe_2O_3 (total Fe)	1.09	2.63
MgO	2.75	2.93
CaO	38.94	14.60
Na_2O	Trace.	.93
K_2O	Trace.	1.76
H_2O	1.67	4.96
TiO_2	....	.38
P_2O_5	.23	.20
CO_2	29.57	12.40
SO_3	.53	....
Cl	.11	....
MnO	Trace.	Trace.
Organic matter	2.96	....
	100.35	100.37

NEW MEXICO AND ARIZONA.

A. Adobe soil, Santa Fe, N. Mex.

B. Adobe soil, Fort Wingate, N. Mex.

Analyses A and B by L. G. Eakins, record No. 981.

C. Clay, Salt River Valley, Ariz.

D. Clay, about 1 mile from C.

Analyses C, D by E. T. Allen, record Nos. 1945, 1959.

	A	B	C	D
SiO_2	66.69	26.67	50.51	50.55
Al_2O_3	14.16	.91	14.63	14.89
Fe_2O_3	4.38	.64	5.03	4.98
MgO	1.28	.51	3.00	2.91
CaO	2.49	36.40	6.77	4.82
Na_2O	.67	Trace.	2.18	4.12
K_2O	1.21	Trace.	3.06	3.19
H_2O-	4.94	2.26	[a] 13.30	4.75
H_2O+				6.00
TiO_2	....	....	.66	.58
CO_2	.77	25.84	....	2.81
P_2O_5	.29	.75	Undet.	....
SO_3	.41	.82	....	None.
Cl	.34	.07	.20	....
MnO	.09	Trace.	.03	Trace.
BaO	....	....	....	.05
Organic matter	2.00	5.10	....	....
	99.72	99.97	99.37	99.65

[a] Loss on ignition.

NEVADA.

A. Grayish clay from upper Lahontan lake beds, Humboldt River bridge, Mill City.

B. Grayish clay, lower Lahontan beds, same locality. Analyses by T. M. Chatard, record Nos. 32, 33.

C. Adobe soil, Humboldt. Analysis by L. G. Eakins, record No. 981.

	A	B	C
SiO_2	56.30	50.70	44.64
Al_2O_3	16.52	19.01	13.19
Fe_2O_3	5.08		5.12
MgO	2.64	3.19	2.96
CaO	5.45	10.26	13.91
Na_2O	2.60	1.91	.59
K_2O	2.17	2.16	1.71
H_2O	9.78	13.03	3.89
P_2O_5			.94
MnO			.13
CuO			
CO_2			8.55
SO_3			.64
Cl			.14
Organic matter			3.43
	100.54	100.26	99.84

CALIFORNIA, WASHINGTON, AND HAWAIIAN ISLANDS.

A. Sandy clay, Owens Lake, Cal.

B. Blue clay, Owens Lake, Cal. Analyses by T. M. Chatard, record No. 551.

C. Supposed bentonite, Randsburg quadrangle, California. Received from F. L. Hess. Analysis by G. Steiger, record No. 2761.

D. Clay from foot of Rickey Hill, Kittle Falls, Stevens County, Wash. Analysis by W. F. Hillebrand, record No. 1428.

E. Typical wheat soil, plateau south of Krupp, Wash.

F. Residuary soil from basalt, Hausen Creek, Kittitas County, Wash. Analyses E and F by George Steiger, record No. 2028.

G. Lava soil, Diamond Head, Hawaiian Islands. Analysis by L. G. Eakins, record No. 888.

	A	B	C	D	E	F	G
SiO_2	53.24	54.92	64.45	62.74	65.43	52.95	32.88
Al_2O_3	10.84	11.25	14.75	16.45	13.96	15.69	12.02
Fe_2O_3	2.59	2.77	1.28	2.62	5.35	11.85	11.52
FeO	.77	.94		1.91			
MgO	5.82	4.91	3.21	2.41	1.54	2.04	11.70
CaO	9.18	8.76	1.73	3.68	2.90	4.40	12.20
Na_2O	2.06	2.10	1.97	3.05	2.42	2.09	Undet.
K_2O	2.64	2.77	.83	3.53	2.08	1.11	Undet.
H_2O-	1.41	2.05	7.05	2.69	2.32	2.19	5.30
H_2O+	2.73	2.40	[a] 5.12		2.42	4.01	
TiO_2	.25	.30			.87	2.57	
P_2O_5			.04		.20	.19	.24
MnO	.10	.08		Trace.			Trace.
SrO				Trace.			
CO_2	8.75	7.24		.65	None.	None.	11.41
SO_3	.08	Trace.	None.				
Cl	.05	Trace.					.91
C, organic					.49	.63	
	100.51	100.49	100.43	99.73	99.98	99.72	98.18

[a] Includes some CO_2.

ARGENTINA.

Earths collected by A. Hrdlička, and described by F. E. Wright and C. N. Fenner in Bull. 52, U. S. Bureau of Ethnology. Analyses by J. G. Fairchild, record No. 2588.

A. Loess, Alvear, on the Parana.

B. Burnt clay, "tierra cocida," Alvear.
C. Scoria and adjacent loess, 3 miles north of Miramar.
D. "Tierra cocida," Miramar.
E. Scoria, north of Necochea.
F. Scoria, coast north of San Blas.

	A	B	C	D	E	F
SiO_2	66.81	65.67	61.30	62.49	56.27	56.09
Al_2O_3	15.04	16.25	14.15	16.45	12.79	16.04
Fe_2O_3	3.11	4.89	.91	4.30	2.55	8.81
FeO	Trace.	Trace.	2.86	.65	7.24	.90
MgO	1.03	.87	2.46	1.56	3.14	3.21
CaO	1.65	1.44	4.63	3.62	8.89	6.09
Na_2O	1.79	1.66	5.47	3.45	4.07	3.68
K_2O	2.31	2.29	3.62	2.26	1.96	1.79
H_2O-	3.34	1.98	.24	2.44	.36	.43
H_2O+	4.07	3.44	2.03	2.44	.44	.49
TiO_2	.65	.90	.54	.57	2.62	1.67
P_2O_5	.06	Trace.	.71	Trace.	.23	.29
S	Trace.	Trace.	.03	Trace.	Trace.	None.
MnO	.12	.12	.08	None.	None.	None.
	99.98	99.51	99.03	100.23	100.56	99.49

CO_2 absent from all.

OCEANIC CLAYS.

Composite analyses of sediments collected by various exploring expeditions. Material contributed by Sir John Murray. The larger number of samples was collected by the *Challenger* expedition.

A. The red clay. Composite of 51 samples, dredged from the sea bottom in all the great oceans.

B. The portion of A soluble in water. Analyses by G. Steiger, record No. 2300. Additional determinations by Hillebrand revealed the presence in the clay of traces of molybdenum, and E. C. Sullivan also found the following percentages of heavy metals: CuO, 0.02; PbO, 0.007; ZnO, 0.004; As_2O_3, 0.0007.

C. Terrigenous clays, dredged at depths from 140 to 2,120 fathoms. Composite of 52 samples. Supplementary determinations gave the subjoined percentages of heavy metals: Pb, 0.0004; Cu, 0.0072; Zn, 0.007; Ni, Co, 0.063; As, a trace.

D. The portion of C soluble in water. Analyses by Steiger, Nos. 2323, 2715. Analyses B, D, represent merely adherent sea salts.

	A	B	C	D
SiO_2	45.32	....	46.64	0.14
Al_2O_3	13.26	....	14.08	
Fe_2O_3	7.20	....	4.14	
FeO	.70	....	1.88	
MgO	3.05	.21	1.95	.18
CaO	6.82	.19	7.20	.38
Na_2O	3.63	2.01	2.98	2.12
K_2O	2.43		1.84	....
H_2O-	3.28	....	4.73	....
H_2O+	5.93	....	5.86	....
TiO_2	.82	....	1.04	....
CO_2	3.91	....	4.05	....
P_2O_5	.25	....	.17	....
SO_3	.48	.39	.32	....
S	Trace?	....	.11	....
Cl	2.77	2.73	2.25	2.25
(Ni, Co)O	.032	....	....	....
MnO	.83	....	.10	....
BaO	.17	....	.05	....
SrO	.046	....	.025	....
V_2O_3	.028	....	.028	....
Cr_2O_3	.01	....	.044	....
CuO	.02	....	.016	....
C	....	....	1.38	....
	100.986	5.53	100.883	5.07
Less O	.62	....	.56	....
	100.366	....	100.323	....

ANALYSES OF METEORITES.

STONY METEORITES.

1. ROCKWOOD, TENN.

From the Crab Orchard Mountains, Cumberland County, about 8½ miles west of Rockwood. Analyzed by J. E. Whitfield, record No. 735, and described by him in Bull. 60, p. 103.

A. Analysis of the material as a whole.

B. Nickel-iron separated. Forms not over 16 per cent of the mass.

C. Nodule from meteorite.

D. Portion of nodule, 94 per cent, insoluble in hydrochloric acid. May be enstatite.

The stony part of the meteorite appears to be mainly pyroxene and anorthite. Fe_2O_3 was not determined, and FeO represents the total iron oxide.

	A	B	C	D
SiO_2	41.92		49.96	51.85
Al_2O_3	9.27		4.75	4.52
FeO	22.94		15.97	13.26
CaO	9.09		1.15	1.09
MgO	8.76		28.15	29.28
Fe	3.75	87.59		
Ni	1.74	12.09		
Co	Trace.	Trace.		
Cu	Trace.	Trace.		
P	.65			
S	1.58			
Cl	.18			
	99.88	99.68	99.98	100.00

2. HAMBLEN COUNTY, TENN.

Mass of nearly half-and-half stone and iron found about 6 miles WSW. of Morristown. Analyzed by L. G. Eakins, and described in Bull. 113, p. 61.

A. The nickel-iron.

B. The part of the stony portion soluble in hydrochloric acid; 37.63 per cent, recalculated to 100, with sulphur deducted.

C. Insoluble part of the stony portion; 62.10 per cent, recalculated to 100.

A petrographic description of this meteorite and an analysis of the feldspar are given by Merrill in Am. Jour. Sci., 4th ser., vol. 2, p. 149. He finds that the meteorite contains, in addition to the nickel-iron, enstatite, diallage, anorthite, olivine or monticellite, oldhamite or secondary gypsum derived from oldhamite, lawrenceite, troilite, and schreibersite.

	A		B	C
Fe	90.92	SiO_2	45.61	50.67
Ni	7.71	Al_2O_3	22.62	14.89
Co	.80	Cr_2O_3		1.32
Cu	Trace.	FeO	11.73	10.55
P	.19	NiO	1.06	
S	.04	MnO		.76
		CaO	14.09	3.61
		MgO	3.64	17.98
		K_2O		.03
		Na_2O		.19
		P_2O_5	1.25	
		S		
	99.66		100.00	100.00

3. ALLEGAN, MICH.

Fell July 10, 1899, on Thomas Hill, Allegan. Analyses by H. N. Stokes, record No. 1856. Described by Merrill and Stokes in Proc. Washington Acad. Sci., vol. 2, p. 41. Sp. gr., 3.905 at 27°, Merrill.

A. Composition of the meteorite as a whole.

B. The metallic portion, analyzed separately.

C. Partial analysis of separated chromite.

D. Composition of the stony portion.

E. Stony material soluble in hydrochloric acid.

F. Stony material insoluble in hydrochloric acid.

The stony matter of the meteorite consisted mainly of olivine and enstatite, and amounted to 76.94 per cent. The metallic portion formed 23.06 per cent. Troilite was present and appears in the analysis of the stony portion.

	A	B	C	D	E	F
SiO_2	34.95	....	....	45.42	17.26	28.17
TiO_2	.08	....	1.20	.10	Trace.	.11
Al_2O_3	2.55	....	9.67	3.31	.67	2.41
Cr_2O_3	.53	....	50.31	.69	.04	.62
FeO	8.47	....	28.78	11.02	6.91	4.16
FeS	5.05	....	....	6.57	6.79	None.
MnO	.18	....	....	.23	.09	.08
NiO	Trace.	....	....	Trace.	....	....
CaO	1.73	....	....	2.24	.49	1.64
MgO	21.99	....	2.76	28.60	17.17	11.57
K_2O	.23	....	....	.30	.18	.14
Na_2O	.66	....	....	.86	.08	.84
Li_2O	Trace.	....	....	Trace.	....	....
H_2O-	.06	....	....	.07	....	....
H_2O+	.19	....	....	.24	....	....
P_2O_5	.27	....	....	.35	.35	Trace.
Fe	21.09	91.42	....	....	....	....
Cu	.01	.046	....	....	....	....
Ni	1.81	7.87	....	....	....	....
Co	.15	.66	....	....	....	....
	100.00	99.906	....	100.00	50.03	99.74

4. WINNEBAGO COUNTY, IOWA.

Fell May 2, 1890. Sp. gr., 3.804, 28.5°. Analyzed by L. G. Eakins, record No. 1190, and described in Bull. 78, p. 95.

Composition of the mass.

Nickel-iron	19.40
Troilite	6.19
Soluble silicates	36.04
Insoluble silicates	38.37
	100.00

Separate analyses:

A. The nickel-iron.

B. Silicate soluble in hydrochloric acid, calculated to 100 per cent.

C. Insoluble silicate, recalculated to 100 per cent. The Cr_2O_3 probably represents chromite.

	A		B	C
Fe	92.65	SiO_2	39.74	55.51
Ni	6.11	Al_2O_3	....	5.43
Co	.65	Cr_2O_3	....	.25
P	Trace.	FeO	18.42	9.45
S	Trace.	NiO	.38	....
		MnO	Trace.	....
		CaO	.69	3.00
		MgO	40.77	24.09
		K_2O	Trace.	.15
		Na_2O	Trace.	2.12
		P_2O_5	Trace.	....
	99.41		100.00	100.00

5. TANEY COUNTY, MO.

Analysis by J. E. Whitfield, record No. 736. See Bull. 60, p. 106. Sp. gr., 4.484.

A. The separated nickel-iron.
B. The stony portion as a whole.
C. Silicates soluble in hydrochloric acid, recalculated to 100 per cent.
D. Insoluble silicates, recalculated to 100 per cent.

	A		B	C	D
Fe	89.41	SiO_2	45.88	26.95	52.39
Ni	10.41	Al_2O_3	7.89	17.69	7.11
Co	.29	FeO	19.73	35.98	14.68
P	.16	CaO	6.02	15.98	4.49
		MgO	17.96	3.40	21.33
		NiS	1.67	....	....
		FeS	.54	....	....
	100.27		99.69	100.00	100.00

6. WASHINGTON COUNTY, KANS.

Fell July 25, 1890. Analyzed by L. G. Eakins, record No. 1227, and described in Bull. 90, p. 45. Sp. gr., 3.49, 21.6°.

Composition of the mass.

Nickel-iron	7.7
Troilite	5.0
Soluble silicates	46.0
Insoluble silicates	41.5
	100.2

Separate analyses.

A. The nickel-iron.
B. Silicates soluble in hydrochloric acid, calculated to 100 per cent.
C. Insoluble silicates, calculated to 100 per cent.

	A		B	C
Fe	86.76	SiO_2	38.50	53.80
Ni	12.18	Al_2O_3	....	4.32
Co	.83	Cr_2O_3	....	1.41
		FeO	23.54	11.98
		NiO	.69	....
		CoO	Trace.	....
		MnO	.34	Trace.
		CaO	.12	4.08
		MgO	36.81	22.37
		K_2O	....	.27
		Na_2O	....	1.77
	99.77		100.00	100.00

7. KIOWA COUNTY, KANS.

A pallasite found in Brenham Township. Analyzed by L. G. Eakins, record No. 1188, and described in Bull. 78, p. 94.

A. The nickel-iron. Sp. gr., 7.93, 23.4°.
B. The pure olivine. Sp. gr., 3.376, 23.2°.
C. Dark outer zone of olivine, containing troilite.

	A		B	C
Fe	88.49	SiO_2	40.70	34.14
Ni	10.35	Al_2O_3	Trace?	....
Co	.57	Fe_2O_3	.18	....
Cu	.03	FeO	10.79	23.20
P	.14	NiO	.02	Trace.
S	.08	CoO	....	.03
Si	Trace?	MnO	.14	.09
C	Trace.	MgO	48.02	40.19
		S	....	.542
			99.85	103.07
		Less O=S	....	2.71
	99.66			100.36

8. TRAVIS COUNTY, TEX.

Analyzed by L. G. Eakins, record No. 1097, and described in Bull. 78, p. 91. Sp. gr., 3.543, 20°. According to Cross, the stony portion contains olivine and enstatite, with a small amount of a colorless mineral, which is probably feldspar. Chromite is also present.

Approximate composition of the mass.

Nickel-iron	2.23
Troilite	5.03
Soluble silicates	39.84
Insoluble silicates	52.42
	99.52

A. Total analysis.

B. Nickel-iron.

C. Silicates soluble in hydrochloric acid, calculated to 100 per cent.

D. Insoluble silicates, calculated to 100 per cent.

	A	B	C	D
SiO_2	44.75	....	38.13	56.14
Al_2O_3	2.72	....	2.58	3.73
Cr_2O_3	.52	....	....	1.00
CuO	Trace.	....	....	....
FeO	16.04	....	19.76	9.15
Fe	1.83	88.74	....	....
NiO	.52	....	1.19	....
Ni	.22	10.68	....	....
Co	.01	.58	....	....
MnO	Trace.	....	....	....
CaO	2.23	....	1.02	3.59
MgO	27.93	....	37.32	24.44
K_2O	.13	....	Undet.	.19
Na_2O	1.13	....	Undet.	1.76
P_2O_5	.41	....	....	....
S	1.83	....	....	....
H_2O	.84	....	....	....
	101.11	100.00	100.00	100.00
Less O=S	.92	....	....	....
	100.19	....	....	....

9. BLUFF, FAYETTE COUNTY, TEX.

Analyzed by J. E. Whitfield, record No. 824, and described in Bull. 60, p. 107. Sp. gr., 3.510. Examined microscopically by G. P. Merrill, who reports, in addition to nickel-iron and pyrrhotite, olivine, enstatite, and what appears to be augite or an allied pyroxene. See Am. Jour. Sci., 3d ser., vol. 36, August, 1888.

A. Total analysis.

B. Nickel-iron (5.67 per cent of total).

C. Part soluble in hydrochloric acid, calculated to 100 per cent (60.62 per cent of total).

D. Insoluble part, calculated to 100 per cent (33.3 per cent of total).

	A	B	C	D.
SiO_2	37.70	....	33.59	49.64
Al_2O_3	2.17	....	1.34	4.12
FeO	23.82	....	31.12	15.56
Fe	4.41	82.42	....	....
NiO	1.59	....	2.66	Trace.
Ni	.88	15.44	....	....
CoO	.16	....	.27	Trace.
Co	.37	2.14	....	....
MnO	.45	....	.43	.54
CaO	2.20	....	1.00	4.93
MgO	25.94	....	28.08	25.21
P_2O_5	.25	....	.42	....
S	1.30	....	2.18	....
	101.24	100.00	101.09	100.00
Less O=S	.65	....	1.09	....
	100.59	....	100.00	....

This meteorite also contained a dark vein of specific gravity 3.585, which carried 2.30 per cent of metallic iron. Analyses, made on less than 0.4 gram of material, gave as follows, recalculated to 100 per cent:

E. Soluble in hydrochloric acid, metal deducted.

F. Insoluble.

	E	F
SiO_2	27.63	56.52
Al_2O_3	2.41	1.51
FeO	34.31	12.35
NiO+CoO	3.27	4.09
CaO	Trace.	Trace.
MgO	32.12	25.53
S	.52	....
	100.26	100.00
	.26	....
Less O=S	100.00	....

E represents 51 per cent and F 44 per cent of the vein.

10. SAN BERNARDINO COUNTY, CAL.

Found in the San Emigdio Mountains. Analyzed by J. E. Whitfield, record Nos. 804 and 936, and described in Bull. 60, p. 114. In fragments, badly altered.

Approximate composition of the mass.

Nickel-iron	6.21
Soluble silicates, etc.	51.26
Insoluble silicates	42.23
	99.70

The soluble part was probably olivine and pyrrhotite, with secondary iron oxide. The insoluble part was enstatite, essentially.

A. The nickel-iron.

B. The enstatite.

	A		B
Fe	88.25	SiO_2	54.42
Ni	11.27	FeO	14.03
Co	.48	CaO	2.46
		MgO	29.11
	100.00		100.02

11. BEAVER CREEK, BRITISH COLUMBIA.

Fell May 26, 1893, near Beaver Creek, West Kootenai district. Described by Howell, Hillebrand, and Merrill in Am. Jour. Sci., 3d ser., vol. 47, p. 430.

Composition of the mass.

Nickel-iron	17.13
Magnetite	.16
Troilite	5.05
Soluble silicates and phosphate	37.23
Insoluble silicates and chromite	40.43
	100.00

According to Merrill, the silicates visible are olivine, enstatite, probably a little plagioclase, and some glassy base.

Analyses by W. F. Hillebrand, record No. 1444.

A. Nickel-iron.

B. Nonmagnetic, stony portion.

C. Portion of B soluble in hydrochloric acid, calculated to 100 per cent.

D. Insoluble portion, calculated to 100 per cent. From C and D troilite and chromite are excluded. The chromite forms about 0.75 per cent of the stony matter.

	A		B	C	D
Fe	90.68	SiO_2	45.87	38.26	57.75
Ni	8.80	TiO_2	.09	....	.18
Co	.49	Al_2O_3	2.30	.56	4.89
Cu	.03	Cr_2O_3	.51	....	....
		FeO	12.68	19.52	8.02
		Fe	3.87	....	....
		NiO	.07	.09	Trace.
		MnO	.26	.27	.35
		CaO	1.96	1.03	3.44
		MgO	28.24	38.74	23.19
		K_2O	.15	.02	.25
		Na_2O	.98	.13	1.87
		H_2O	.34	.70	.06
		P_2O_5	.30	.68	....
		S	2.21	....	....
		Cl	Trace.	Trace.	....
	100.00		99.83	100.00	100.00
		Troilite	6.08	....	....
		Chromite	.75	....	....

12. LLANO DEL INCA, CHILE.

Analyzed by L. G. Eakins, record No. 1201, and described in Bull. 78, p. 97.

Approximate composition of the mass.

Nickel-iron	25.8
Troilite	10.6
Soluble silicates	30.9
Insoluble silicates	32.6
	99.9

Separate analyses.

A. The nickel-iron.

B. Silicates soluble in hydrochloric acid, calculated to 100 per cent.

C. Insoluble silicates, calculated to 100 per cent.

Is the P_2O_5 in B derived from schreibersite?

	A		B	C
Fe	89.77	SiO_2	28.08	53.11
Ni	9.17	Al_2O_3	12.74	2.32
Co	.61	Cr_2O_3	....	.90
		FeO	42.52	18.82
		NiO	2.90	....
		MnO	.20	....
		CaO	9.33	1.75
		MgO	1.98	23.10
		P_2O_5	2.25	....
	99.55		100.00	100.00

METEORIC IRON.

A. The Mount Joy meteorite, found near Two Taverns post office, near Gettysburg, Pa. Analysis by L. G. Eakins, record No. 1318.

B. From Pulaski County, Va. Sp. gr., 7.95, 23°. Analysis by Eakins, No. 1228. Described by Eakins in Bull. 90, p. 45.

C. From Ellenboro, Rutherford County, N. C. Described and analyzed by Eakins, Bull. 78, p. 93. Record No. 1160.

D. From Linnville Mountain, N. C. Analyzed by J. E. Whitfield, record No. 822, and described in Bull. 60, p. 107. Sp. gr., 7.778.

E. From Cherokee County, Ga. Analysis by H. N. Stokes, record No. 1527.

	A	B	C	D	E
Fe	93.80	93.59	88.05	84.56	91.96
Ni	4.81	5.56	10.37	14.95	6.70
Co	.51	.53	.68	.33	.50
Cu	.005	Trace.	.04	....	.03
P	.19	.27	.21	Trace.	.11
S	.01	.01	.08	.12	.01
Si	....	Trace.	.02	None.	Trace.
C	....	....	....	Trace.	Trace?
	99.325	99.96	99.45	99.96	99.31

F. From near Holland's store, Chattooga County, Ga. Analysis by J. E. Whitfield, record No. 765. See Bull. 60, p. 106. Sp. gr., 7.801.

G. From Hamilton County, Tex. Sp. gr., 7.95, 27°. Analysis by L. G. Eakins, record No. 1189. See Bull. 78, p. 95.

H. From Mart, McLennan County, Tex. Analysis by H. N. Stokes, record No. 1857. Described by Merrill and Stokes in Proc. Washington Acad. Sci., vol. 2, p. 51.

I. From near Scottsville, Allen County, Ky. Analysis by Whitfield, record No. 509. See Bull. 55, p. 64.

J. Fell 6 miles east of Cabin Creek, Johnson County, Ark., March 27, 1886. Analysis by Whitfield, record No. 505. See Bull. 55, p. 63.

K. From near Grand Rapids, Mich. Sp. gr., 7.87. Analysis by R. B. Riggs, record No. 296. See Bull. 42, p. 94.

	F	G	H	I	J	K
Fe	94.60	86.54	89.68	94.32	91.87	88.71
Ni	4.97	12.77	9.20	5.01	6.60	10.69
Co	.21	.63	.33	Trace.	Trace.	
Cu		.02	.037			.07
Mg						.02
Mn					Trace.	
P	.21	.16	.158	.16	.41	.26
S	Trace.	.03	.017	.34	.05	.03
Si				None.		
C	Trace.	.11		.12	.15	.13
Chromite			Trace.			
Fe_2O_3			Trace.			
Insoluble					.34	
	99.99	100.26	99.422	99.95	99.42	99.91

L. The El Capitan iron, from near Bonito, N. Mex. Analysis by H. N. Stokes, record No. 1527.

M. From La Bella Roca, Sierra de San Francisco, Mexico, State of Durango. Analysis by J. E. Whitfield, record No. 1037. Bull. 64, p. 28.

N. Troilite nodule from L, outer part, somewhat altered.

O. Troilite nodule N, inner part. Analyses N and O also by Whitfield, record No. 1037.

P. From Puquios, Chile. Sp. gr., 7.93, 25.2°. Analysis by L. G. Eakins, record No. 1181. See Bull. 78, p. 95.

Q. The Abert iron, of unknown origin. Analysis by R. B. Riggs, record No. 356. Sp. gr., 7.89. See Bull. 42, p. 94.

	L	M	N	O	P	Q
Fe	90.51	91.48		9.37	88.67	92.07
Ni	8.40	7.92			9.83	7.01
Co	.60	.22			.71	.66
Cu	.05				.04	
P	.24	.21			.17	.08
S	Trace.	.21			.09	.01
Si					Trace?	
C		.06			.04	.05
NiS			2.07	2.13		
FeS			37.51	85.27		
Fe_2O_3			37.80			
Moisture			19.85			
	99.80	100.10	97.23	96.77	99.55	99.88

The two following meteoric irons were analyzed by L. G. Eakins in the Denver laboratory.

A. Found near Albuquerque, N. Mex. Described by Eakins in Proc. Colorado Sci. Soc., vol. 2, p. 14.

B. From Wyoming. Partial analysis.

	A	B
Fe	88.76	89.26
Ni	9.86	5.94
Co	.51	.78
Cu	.034	
Zn	.03	
Mn	Trace.	
P	.182	.24
S	.012	
Si	.044	
C	Undet.	
	99.432	96.22

ANALYSES OF MINERALS.

In the following pages the analyses of over 250 distinct minerals are given, a considerable number of which were originally described by chemists connected with the Survey. These species are antlerite, arizonite, beaverite, coronadite, cuprobismutite, custerite, elpasolite, emmonsite, ferritungstite, fremontite, goldfieldite, guitermanite, hinsdalite, hodgkinsonite, hulsite, hydronephelite, inyoite, josephinite, knoxvillite, koechlinite, lucasite, meyerhofferite, morencite, paigeite, palaite, plumbojarosite, powellite, ptilolite, purpurite, redingtonite, salmonsite, sicklerite, warrenite, and zunyite. Other minerals which were imperfectly described have been more sharply characterized and their true composition made known. Natrojarosite, for example, is here definitely recognized as a species, and the ochres of bismuth, molybdenum, and tungsten are properly classified.

In general the order of Dana's classification has been followed, but with some small variations. Thus the tellurides are put in a group by themselves, the borosilicates are brought together, and the phosphates, vanadates, and arsenates are given as three separate classes. On purely chemical grounds these changes are warranted; on morphological grounds the usual mineralogical classification may be better.

I. NATIVE ELEMENTS.

GOLD.

From Persia; exact locality unknown. Analyzed by Charles Catlett.

Au	93.24
Ag	6.65
Fe	.11
Cu	None
	100.00

JOSEPHINITE.[a]

A nickel-iron alloy found in placer gravels in Jackson and Josephine counties, Oreg. Described as a new species by W. H. Melville, Am. Jour. Sci., 3d ser., vol. 43, 1892, p. 509. Waterworn pebbles. Sp. gr., 6.204.

Ni	60.45	Cl	0.04
Co	.55	Silicates (anhydrous)	12.26
Fe	23.22	H_2O-	.81
Pyrrhotite	.55	H_2O+	1.12
Chromite Magnetite	.12	Volatile matter	.70
Cu	.50	CO_2	Trace
As	.23		100.55

The silicate admixture, including the water, amounts to 13.38 per cent, of which 12.88 per cent, soluble in hydrochloric acid, is serpentine. The insoluble portion may be bronzite. Analyses of the silicates are as follows:

	Total.	Insoluble portion.	Soluble portion.
SiO_2	5.14	0.23	4.91
Al_2O_3	.33	.03	.30
Fe_2O_3	2.08	.04	2.04
NiO, CoO	.32	Trace.	.32
CaO	1.62	.06	1.56
MgO	2.69	.14	2.55
Na_2O	.08	....	.08
H_2O+	1.12	....	1.12
	13.38	.50	12.88

---

[a] Possibly identical with awaruite.

II. SULPHIDES, ARSENIDES, AND ANTIMONIDES.

BISMUTHINITE.

From the Rosario mining district, Sinaloa, Mexico. Analysis by W. H. Melville. Described by him in Bull. 90.

Bi	72.90
Pb	6.03
Cu	1.67
Fe	.35
S	18.11
Quartz	.63
	99.69

METACINNABARITE.

Crystallized material from New Almaden, Cal. Analysis by W. H. Melville. Not free from admixtures.

Hg	78.01
S	13.68
Fe	.61
Co	Trace.
Zn	.90
Mn	.15
$CaCO_3$	.71
Quartz	4.57
Organic matter	.63
	99.26

Another specimen of metacinnabarite from Knoxville, Cal., gave Melville the following figures:

HgS	98.48
FeS	.69
SiO_2	.71
	99.88

The latter mineral was described by Melville and Lindgren in Bull. 61.

COVELLITE.

From the East Greyrock mine, Butte, Mont. Collected by G. W. Tower. Analysis by W. F. Hillebrand. Color, indigo blue. Massive. Sp. gr., 4.76 at 26°.

Cu	66.06
S	33.87
Fe	.14
Insoluble	.11
	100.18

POLYDYMITE.

A massive ore from the mine of the Canadian Copper Co., Sudbury, district of Algoma, Ontario. Specific gravity, 4.541. Analysis by Charles Catlett. Described by Clarke and Catlett in Am. Jour. Sci., 3d ser., vol. 37, 1889, p. 372. Composition nearly Ni_3FeS_5.

A. Actual analysis.

B. Analysis corrected by deduction of quartz and chalcopyrite.

	A	B
Ni	41.96	43.18
Fe	15.57	15.47
S	40.80	41.35
Cu	.62	....
SiO_2	1.02	....
	99.97	100.00

Another nickel-iron sulphide, from the Worthington mine, Sault branch of the Canadian Pacific Railway, 25 miles west of Sudbury, has been analyzed by W. F. Hillebrand. Grayish, with a cast of yellow. Not pyrrhotite. Possibly a mixture of polydymite and pyrite.

Fe	38.36
Ni	4.57
Mn	.10
S	45.11
SO_3	.95
CO_2	[a] 1.49
CaO	1.91
MgO	.41
H_2O	.55
Insoluble	4.80
	98.25

Still another nickel-iron sulphide is described by Hillebrand in Jour. Am. Chem. Soc., vol. 29, p. 1027. It is found in association with the patronite of Minasragra, Peru, and appears to be a new species with the formula $(NiFe)S_2$. For this the provisional name bravoite is suggested. Analysis by Hillebrand. The deficiency is possibly due to the partial oxidation of the vanadium present. The latter represents unseparated patronite.

S	45.06
Fe	25.38
Ni	15.70
Co	Trace.
V	4.31
Mo	.09
C	.47
H_2O	[b] 1.38
TiO_2	.93
SiO_2	1.93
Al_2O_3	[c] 2.45
	97.70

PYRITE.

From the Henrietta Maid mine, Leadville, Colo. Analysis by R. C. Wells. Sp. gr., 4.725.

Fe	46.26
S	53.25
TiO_2	.11
SiO_2	.068
Cu	.078
Ag	.017
Zn	.005
As	.007
CaO	.004
MgO	.065
$FeSO_4$	.33
H_2O	.18
CO_2	.08
	100.454

STROMEYERITE.

From the Silver King mine, Calico, San Bernardino County, Cal. Sp. gr., 6.28. Analysis by W. H. Melville. Described by Melville and Lindgren in Bull. 61.

Ag	53.96
Cu	28.58
Fe	.26
S	15.51
Residue	1.55
	99.86

---

[a] Calculated to saturate CaO. [b] Partly from H of carbonaceous matter. [c] Includes a little P_2O_5.

SUPLHIDE OF SILVER, COPPER, AND ZINC.

Massive, resembling bornite. Apparently homogeneous, but may be a mixture. Sp. gr., 5.407 at 20°. Analyzed by W. F. Hillebrand and described in Bull. 55. From the Gagnon mine, Butte, Mont.

Cu	40.24
Ag	21.80
Pb	1.46
Zn	12.83
Fe	1.98
S	20.88
	99.19

ARSENOPYRITE.

From Franklin Furnace, N. J. Approximate analysis on only 0.25 gram of material by E. C. Sullivan. Notable as containing cobalt. The arsenic is probably a trifle too high.

Fe	32.48
Co	1.16
As	48.72
S	18.80
	101.16

GLAUCODOT.

From the Standard Consolidated gold mine, Sumpter, Oreg. Analyzed by W. T. Schaller, and described in Bull. 262, p. 132.

A. Analysis as made.

B. Analysis recalculated to 100 per cent, after deducting gangue.

	A	B
As	39.84	43.79
S	18.46	20.29
Fe	12.45	13.68
Co	20.23	22.24
Insoluble	9.38	......
	100.36	100.00

PATRONITE.

The vanadium sulphide from Minasragra, Peru. Analyzed by W. F. Hillebrand, and described in Jour. Am. Chem. Soc., vol. 29, p. 1019.

S	58.79
V	19.53
Mo	.18
Fe	2.92
Ni	1.87
C	3.47
SiO_2	6.88
TiO_2	1.53
$Al_2O_3(P_2O_5)$	2.00
Fe_2O_3	.20
MnO	Trace.
Cr	Trace?
Alkalies	.10?
H_2O	1.90
O from vanadium sulphate	.38
	99.75

Of the sulphur, 4.5 per cent is free, the remainder is combined. The oxidized constituents represent impurities and gangue.

ENARGITE.

From the Rarus mine, Butte, Mont. Collected by G. W. Tower. Analysis by W. F. Hillebrand.

Cu	48.67
Fe	.33
Zn	.10
As	17.91
Sb	1.76
S	31.44
Insoluble	.11
	100.32

CUPROBISMUTITE.

New species, discovered by W. F. Hillebrand and described by him in Bull. 20. Named by Dana. Sp. gr., 6.680 at 15°, corrected for impurities. From the Missouri mine, Halls Valley, Park County, Colo. Analyses, by Hillebrand, of three different samples.

	A	B	C
Bi	60.74	63.36	62.45
Ag	.89	4.09	9.89
Cu	15.96	12.65	6.68
Pb	....	....	2.74
Fe	2.13	.59	.10
Zn	.10	.07	.07
S	[a] 19.94	[a] 18.83	17.90
	99.76	99.59	99.83

[a] Calculated.

ZINKENITE.

From the Brobdignag mine, Red Mountain, San Juan County, Colo. Sp. gr., 5.21 at 18°. Analyzed by W. F. Hillebrand and described by him in Bull. 20.

	A	B
Sb	35.00	....
As	5.64	5.59
Pb	32.77	32.79
Cu	1.20	....
Ag	.23	....
Fe	.02	....
CaO	.31	....
Alkalies	.45	....
S	22.50	22.50
Gangue	.59	....
	98.71	....

GALENOBISMUTITE.

From the Germania mine, in northeast Washington. Analysis by R. C. Wells, on rather scanty material.

Bi	56.92
Pb	25.24
S	17.03
Gangue	1.66
	100.85

WARRENITE.[1]

New species, described by L. G. Eakins in Am. Jour. Sci., 3d ser., vol. 36, 1888, p. 450. From the Domingo mine, Gunnison County, Colo. Occurs in matted, fibrous masses, known locally as "mineral wool." Analysis by Eakins.

Pb	39.33
Sb	36.34
S	21.19
Ag	Trace.
Fe	1.77
Mn	Trace.
Insoluble	.52
	99.15

COSALITE.

A. From the Comstock mine, near Parrott City, La Plata County, Colo. Analysis by W. F. Hillebrand. Described by Hillebrand in Bull. 20.

B. From the Tungsten King mine, near Deer Park, Stevens County, Wash. Analysis by R. C. Wells.

	A	B
Bi	42.93	45.25
Ag	8.43	.80
Cu	7.50	1.16
Pb	22.49	33.66
Fe	.70	....
Zn	Trace.	....
S	17.11	16.58
Gangue	....	2.19
Moisture	....	.17
	99.16	99.81

FREIESLEBENITE.

From Augusta Mountain, Gunnison County, Colo. Known locally as "mineral wool." Remarkable for its freedom from silver. Analyzed by L. G. Eakins and described by him in Am. Jour. Sci., 3d ser., vol. 36, 1888, p. 452.

Pb	55.52
Sb	25.99
S (calculated)	18.98
Ag	Trace.
Fe	Trace.
Zn	Trace.
	100.49

BOURNONITE.

From Boggs mine, Yavapai County, Ariz. Analysis by W. T. Schaller.

Insoluble	1.67
S	20.04
As	2.81
Sb	18.99
Pb	40.21
Cu	15.12
Fe	.35
Zn	.35
Mn	Trace.
	99.54

---

[1] According to L. J. Spencer, warrenite is identical with jamesonite. W. T. Schaller (Bull. 490, p. 25) regards it as a mixture of zinkenite and jamesonite. It appears to be not a definite species.

LILLIANITE?

A doubtful mineral from Leadville, Colo. Is near lillianite, but also near aikenite and cosalite. Analysis by R. C. Wells.

Bi	37.11
Pb	36.90
Ag	8.58
Cu	.08
Fe	.18
Zn	Trace.
CaO	.03
S	15.18
Insoluble	1.33
	99.39

TETRAHEDRITE.

A. From the Anchor mine, Park City district, Utah. Analysis by G. Steiger.

B. From the Ramshorn mine, Bay Horse district, Custer County, Mont. Analysis by R. C. Wells.

	A	B
Sb	21.30	25.22
As	5.54	1.46
Cu	37.87	33.39
Ag	1.49	4.86
Fe	.95	4.64
Zn	7.58	3.53
Mn	.02	.01
Bi	....	.34
Ni	....	Trace.
S	25.66	25.74
Gangue	....	.08
	100.41	99.27

GUITERMANITE.

New species, discovered by W. F. Hillebrand and described by him in Bulletin 20. From the Zuni mine, Anvil Mountain, near Silverton, San Juan County, Colo. Forms the matrix of zunyite. Corrected specific gravity, 5.94 at 17.5°. Analyses by Hillebrand.

	I	II
Admixed zunyite	1.77	3.82
As	13.40	13.00
Pb	63.60	61.63
Cu	.17	.17
Ag	.02	.02
Fe	.43	.88
S	19.67	19.56
O	....	.55
	99.06	99.63

LÖLLINGITE.

From Teocalli Mountain, Brush Creek, Gunnison County, Colo. Sp. gr., 7.400 at 14.5°, corrected for impurity. Analyzed by W. F. Hillebrand and described in Bull. 20.

As	71.18
S	.56
Bi	.08
Cu	.39
Fe	22.96
Co	4.37
Ni	.21
	99.75

A doubtful arsenide of nickel and cobalt has also been examined by Hillebrand and described in Proc. Colorado Sci. Soc., vol. 3, pt. 1, p. 46. From the Rose mine, Grant County, N. Mex. Sp. gr., 6.644 at 20°. Probably a mixture. Ni:Co=3:1, approximately.

As	74.04
S	.13
Ag	4.78
Cu	.04
Pb	.03
Fe	.44
Ni, Co	19.52
CaO	.09
MgO	.05
	99.12

NICCOLITE.

From Sudbury, Canada. Actually a mixture of 65 per cent niccolite with 35 per cent cobaltite. Analysis by Chase Palmer.

Ni	28.26
Co	12.25
Fe	.46
As	53.02
S	5.89
	99.88

DYSCRASITE.

From Cobalt, Ontario, Canada. Analysis by R. C. Wells.

Ag	84.10
Sb	13.55
Bi	1.06
Hg	.52
Gangue	.05
	99.28

III. TELLURIDES.

HESSITE.

From San Sebastian, Jalisco, Mexico. Sp. gr., 8.24 at 26°. Analysis by W. F. Hillebrand.

Ag	61.16
Te	36.11
Pb	1.90
S, Fe, Zn	Undet.
	99.17

PETZITE.

From the Norwegian mine, Calaveras County, Cal. Collected by F. L. Ransome. Sp. gr., 8.925 at 23°. Analysis by W. F. Hillebrand. Formula, $Au_2Te.3Ag_2Te$.

Ag	41.87
Au	25.16
Te	33.21
Se	Trace.
Mo	.08
	100.32

SYLVANITE.

From the Elkton mine, Cripple Creek, Colo. Analysis by W. F. Hillebrand. Approximate only.

Ag	11.0
Au	26.7
Te	62.3
	100.0

CALAVERITE.

From Cripple Creek, Colo. Collected by R. A. F. Penrose, jr. Analyzed by W. F. Hillebrand and described by him in Bull. 167.

A. From the Prince Albert mine. Corrected sp. gr., 9.0 at 24°.

B. Raven mine.

C. C. O. D. mine.

	A	B	C
Te	57.27	47.69	53.89
Au	38.95	33.93	39.31
Ag	3.21	1.47	.85
Insoluble matter	.33	5.80	.91
Fe_2O_3	.12		
Fe		5.41	1.67
S		[a] 6.17	1.58
Mn			[b] .23
Ca			.51
Mg			.10
O, F, and soluble SiO_2 by difference			.95
	99.88	100.47	100.00

[a] Calculated from Fe to make FeS_2.

[b] As MnO_2?

MELONITE.

From the Melones mine, Carson Hill, Calaveras County, Cal. Collected by F. L. Ransome. Analyzed by W. F. Hillebrand and described by him in Bull. 167. Three samples. Sp. gr. of B, 7.72 at 22.5°, which is probably too high for the pure $NiTe_2$. Sample C is the purest.

	A	B	C
Te	75.29	77.72	80.75
Ni	15.71	17.16	18.31
Co		.10	
Ag	8.44	5.09	.86
	99.44	100.07	99.92

TETRADYMITE.

From near Whitehorn, Fremont County, Colo. Sp. gr., 7.816 at 20°. Analysis by W. F. Hillebrand.

Bi	52.14
Te	46.62
Se	.20
S	.14
Fe_2O_3	.22
Insoluble	.15
	99.47

GOLDFIELDITE.

A new mineral, collected by F. L. Ransome, at Goldfield, Nev., and analyzed by Chase Palmer, has been named goldfieldite. The analysis is only preliminary, for the material was too scanty to admit of the most thorough work. Described by Ransome in P. P. 66, p. 116.

Cu	33.49
S	21.54
Te	17.00
Sb	19.26
As	.68
Bi	6.91
Au	.51
Ag	.18
Gangue	2.00
	101.57

IV. CHLORIDES AND FLUORIDES.

HALITE.

Rock salt from Salton, Cal. Analysis by E. T. Allen.

NaCl	94.54
KCl	.31
Na_2SO_4	3.53
$CaSO_4.2H_2O$	.79
Moisture	.14
Insoluble residue	.50
	99.81

EMBOLITE.

From Broken Hill, Australia. Analysis by L. G. Eakins.

AgCl	59.97
AgBr	39.22
H_2O	.63
	99.82

TERLINGUAITE.

From Terlingua, Tex. See Hillebrand and Schaller, Jour. Am. Chem. Soc., vol. 29, p. 1190. Analysis by Hillebrand, calculated to a gangue-free basis.

Hg	88.61
Cl	7.83
O	3.75
	100.19

Other determinations gave 88.31 and 88.92 per cent of mercury.

EGLESTONITE.

From Terlingua, Tex. See Hillebrand and Schaller, Jour. Am. Chem. Soc., vol. 29, p. 1192. Three analyses by Hillebrand on very small amounts of material.

	A	B	C
Hg	88.33	88.94	89.73
Cl	8.32	8.23	8.12
O	1.72	1.84	1.80
	98.37	99.01	99.65

Calculated to a gangue-free basis.

KLEINITE.

From Terlingua, Tex. See Hillebrand and Schaller, Jour. Am. Chem. Soc., vol. 29, p. 1181. Average of several determinations by Hillebrand, reduced to a gangue-free basis.

Hg	85.86
Cl	7.30
SO_4	3.10
N	2.57
H_2O	1.03
	99.86

FLUORITE.

From Franklin Furnace, N. J. Partial analysis by G. Steiger on insufficient material.

Al	0.18
Fe	.27
Mg	.24
Ca	51.21
Mn	.09
F	45.85
	97.84

CRYOLITE.

From St. Peters Dome, Pikes Peak district, Colo. Described by Cross and Hillebrand in Bull. 20. Massive. Pinkish in color. Sp. gr., 2.972 at 24°. Analysis by W. F. Hillebrand.

Al	12.81
Na	32.40
Ca	.28
F	53.55
Fe_2O_3	.40
H_2O	.30
	99.74

PACHNOLITE.

From St. Peters Dome, Pikes Peak district, Colo. Described by Cross and Hillebrand in Bull. 20. Analyses by W. F. Hillebrand.

A. Compact bluish variety. Sp. gr., 2.980 at 22°

B. Crystalline coating.

C. Fresh, transparent, crystalline material.

D. Carefully selected crystals. Sp. gr., 2.965 at 17°; 2.962 at 22°.

	A	B	C	D
Al	11.94	12.93, 12.92	12.14	12.27
Ca	19.32	15.27, 15.17	18.06	18.04
Mg	.13	1.53		
Na	10.43	10.28	10.23	10.25
K		.13		
H_2O	7.87, 7.95	8.64, 8.79	8.10, 8.11	8.05
F			51.33, 51.28	[a] 51.39
			99.86	100.00

[a] By difference.

ELPASOLITE.

From St. Peters Dome, Pikes Peak district, Colo. Described as a new species by Cross and Hillebrand in Bull. 20. Incomplete analysis on insufficient material, by W. F. Hillebrand. The fluorine was deduced by calculation on the assumption that the metals are fully combined with it.

Al	11.32
Ca	.72
Mg	.22
K	28.94
Na	9.90
F	46.98
	98.08

GEARKSUTITE.

From St. Peters Dome, Pikes Peak district, Colo. Described by Cross and Hillebrand in Bull. 20. Analysis by W. F. Hillebrand.

Al	15.20
Ca	22.30
Na	.10
K	.04
H_2O	15.46
F	42.07
	95.17
Oxygen (loss)	4.83
	100.00

PROSOPITE.

Two samples of prosopite have been analyzed by W. F. Hillebrand, as follows:

A. From St. Peters Dome, Pikes Peak district, Colo. Described by Cross and Hillebrand in Bull. 20. Sp. gr., 2.880 at 23°. Mean of four analyses.

B. Pale green, massive variety, from the Dugway mining district, Tooele County, Utah. Sp. gr., 2.87 at 21°. Described by Hillebrand in Bull. 167.

	A	B
Al	22.02	20.08
Ca	17.28	17.55
Mg	.17	Trace.
K	....	.12
Na	.48	.32
Cu	....	.17
F	33.18	28.00
H_2O	13.46	14.24
	86.59	80.48
Oxygen (loss)	13.41	[a] 19.52
	100.00	100.00

[a] Including a little quartz, undetermined.

TYSONITE.

From Cheyenne Mountain, near Pikes Peak, Colo. Analyzed by W. F. Hillebrand and described by him in Bull. 167. Corrected sp. gr., 6.14 at 28°.

Ce_2O_3 (includes 0.13 ThO_2)	42.89
La_2O_3 group (at. wt. 139.7)	39.31
F	28.71
CO_2	.53
CaO	.18
Na_2O	.30
K_2O and Li_2O	Traces.
Fe_2O_3	.11
	112.03
Less O equivalent to F	12.08
	99.95

V. OXIDES AND HYDROXIDES.

MANGANOSITE.

From Franklin Furnace, N. J. Collected by C. Palache. Analysis by G. Steiger. Sp. gr., 5.364.

MnO	94.59
MnO_2	1.30
ZnO	3.41
MgO	.11
Fe_2O_3	[a].26
H_2O-	.38
H_2O+	.40
	100.45

SiO_2, Al_2O_3, and CaO absent.

MONTROYDITE.

From Terlingua, Tex. See Hillebrand and Schaller, Jour. Am. Chem. Soc., vol. 29, p. 1189. Analysis by W. F. Hillebrand.

Hg	92.74
O	7.49
	100.23

SPINEL.

Variety pleonaste. Separated from a pyroxenite found between South Meadow and Moore creeks, Madison County, Mont. Rock described by Merrill in Proc. U. S. Nat. Mus., vol. 17, p. 659. Sp. gr. of spinel, 3.89 at 32.3°. Analysis by L. G. Eakins.

Al_2O_3	62.09
FeO	17.56
MgO	15.61
Cr_2O_3	2.62
Fe_2O_3	2.10
MnO	Trace.
CaO	.16
SiO_2	.55
	100.69

GAHNITE.

A. From Gilmore's mica mine, Montgomery County, Md., about 12 miles north of Washington, D. C. Color, bottle green. Sp. gr., 4.59. Analyzed by T. M. Chatard and described by him in Bull. 9.

B. Dysluite from Sterling Hill, N. J. Collected by C. Palache. Analysis by W. T. Schaller. Sp. gr., 4.56.

	A	B
Al_2O_3	55.46	47.27
Fe_2O_3	2.77	[a]9.90
MnO		[b].93
ZnO	40.07	37.10
MgO	.59	1.09
CaO		1.01
CuO	Undet.	
CO_2		.38
SiO_2	.57	1.47
H_2O-	[c].30	.89
H_2O+		.32
	99.76	100.36

[a] Total Fe. [b] State of oxidation uncertain. [c] Loss on ignition.

MAGNETITE.

From the Gallatin Range, between Middle and Bozeman creeks, near Bozeman, Mont. Analysis by T. M. Chatard.

Insoluble	0.16
Fe_3O_4	6.70
Al_2O_3	.04
MnO	.93
CaO	Trace.
MgO	.07
TiO_2	2.71
P_2O_5	.012
S	.171
	100.793
Less O equivalent to S	.06
	100.733

FRANKLINITE.

From Franklin Furnace, N. J. Collected by C. Palache. Analysis by W. T. Schaller. Sp. gr., 5.09.

Fe_2O_3	[a] 66.58
MnO	[a] 9.96
ZnO	20.77
MgO	.34
CaO	.43
SiO_2	.72
H_2O	.71
	99.51

CHROMITE.

From Corundum Hill, N. C. Analysis by T. M. Chatard. Fe_2O_3 not separately determined.

Cr_2O_3	45.94
FeO	42.90
Al_2O_3	2.51
MnO	.84
NiO, CoO	.16
CaO	1.40
MgO	2.81
CuO	.40
SiO_2	3.26
TiO_2	.30
P_2O_5	.12
	100.64

RUTILE.

From near St. Peters Dome, Pikes Peak district, Colo. Sp. gr., 4.288 at 19°. Analysis by L. G. Eakins.

TiO_2	94.93
FeO	3.77
SiO_2	1.37
H_2O	.71
	100.78

---

[a] State of oxidation uncertain.

HYDROPHANE.

From Gibbon Basin, Yellowstone National Park. Analysis by J. E. Whitfield. Sp. gr., 1.97.

SiO_2	97.51
H_2O	2.40
Fe_2O_3	.09
	100.00

DIASPORE.

From Mount Robinson, Custer County, Colo. Analysis by L. G. Eakins.

Al_2O_3	83.97
H_2O	15.43
	99.40

BAUXITE.

Two samples from Jacksonville, Calhoun County, Ala. Alkalies, lime, and magnesia not looked for. Analyses by W. F. Hillebrand.

	Red.	White.
Al_2O_3	41.00	48.92
Fe_2O_3	25.25	2.14
H_2O-	.65	.45
H_2O+	20.43	23.41
SiO_2	10.25	21.08
TiO_2	2.53	2.52
P_2O_5	Trace.	Trace.
	100.11	98.52

BRUCITE.

From Texas, Lancaster County, Pa. Analysis by E. A. Schneider.

MgO	67.97
MnO	.97
Fe_2O_3	.39
H_2O-	.18
H_2O+	30.63
	100.14

PSILOMELANE.

From a prospect hole on plain south of Round Mountain, Silver Cliff, Colo. Analysis by W. F. Hillebrand. There were strong spectroscopic reactions for strontia and lithia, but these bases were not estimated. A little insoluble gangue is included with the silica.

MnO_2	76.18
MnO	5.71
H_2O-	1.41
H_2O+	3.94
Al_2O_3	1.81
Fe_2O_3	.34
CoO	Trace.
ZnO	2.80
CaO	.83
MgO	.29
K_2O	3.46
Na_2O	.81
Sb_2O_5	.12
SiO_2	2.30
	100.00

HETÆROLITE.

From Sterling Hill, N. J. Collected by C. Palache. Analysis by W. T. Schaller. Sp. gr., 4.85.

Mn_3O_4	60.44
Fe_2O_3 [a]	.77
ZnO	33.43
SiO_2	1.71
H_2O-	2.47
H_2O+	1.42
	100.24

Al_2O_3, CaO, and MgO absent.

CORONADITE.

New mineral from the Coronado vein, Clifton-Morenci district, Ariz. Described by Lindgren and Hillebrand in Bull. 262, p. 42. Sp. gr., 5.246 at 22°. Analysis by W. F. Hillebrand.

MnO_2	56.13
MnO	6.56
PbO	26.48
ZnO	.10
CuO	.05
MoO_3	.34
Al_2O_3	[b] .63
Fe_2O_3	[c] 1.01
H_2O	1.03
Insol. and SiO_2	7.22
CaO, MgO, alkalies and loss	.45
	100.00

BISMITE.

Bismuth ocher from the Stewart mine, Pala, Cal. Associated with pucherite. See p. 341. Analyzed by W. T. Schaller and described in Jour. Am. Chem. Soc., vol. 33, p. 1911. Analysis made on only 0.0953 gram of material.

Bi_2O_3	64.9
V_2O_5	.8
H_2O-	.4
H_2O+	11.7
Gangue	23.0
	100.8

VI. CARBONATES.

CALCITE.

From the Gibraltar mine, Bullfrog district, Nev. Analysis by Chase Palmer.

SiO_2	8.59
Fe_2O_3	.10
FeO	.13
MnO	.93
CaO	50.50
CO_2	39.33
	99.58

---

[a] State of oxidation uncertain. [b] Includes a little TiO_2, P_2O_5, and V_2O_5. [c] State of oxidation unknown.

DOLOMITE.

A. Dolomite marble, New York Quarry Co., Tuckahoe, Westchester County, N. Y. Analysis by W. F. Hillebrand.

B. Dolomite marble, Cockeysville, Md. Analysis by J. E. Whitfield.

C. Same as B. Analysis by E. A. Schneider. Another sample.

D. Dolomite marble, Webster, Mass. Analysis by H. N. Stokes.

E. Pink, crystallized dolomite, Joplin, Mo. Analysis by E. T. Allen.

	A	B	C	D	E
Insoluble	0.62		5.57		
SiO_2	.71	0.44		1.01	
Al_2O_3		1.22	.40	.17	
Fe_2O_3	.21			None.	
FeO		Trace.		.37	0.90
MnO				.08	.06
MgO	20.71	20.87	20.30	21.35	19.65
CaO	30.68	30.73	29.08	30.82	32.05
CO_2	46.66	45.85	44.26	45.84	46.82
H_2O	.16	1.22		.09	.48
K_2O				.10	
Na_2O				.01	
P_2O_5				.06	
TiO_2				Trace.	
S				Trace.	
	99.75	100.33	99.61	99.90	99.96

MAGNESITE.

A. From Frisco district, Utah. Analysis by R. C. Wells.

B. C, D, E. From Bissell, Kern County, Cal.

F. From Larious Creek, San Benito County, Cal.

Analyses, partial only, of B to F, by J. G. Fairchild. Descriptions by H. S. Gale in Bull. 540 s.

	A	B	C	D	E	F
Insoluble	0.27					
SiO_2		9.64	8.51	6.03	4.75	0.14
MgO	42.77	37.19	38.32	42.78	44.20	47.07
CaO	4.72	4.25	3.36	1.56	Trace.	.59
CO_2	[a] 50.71	40.70	40.12	45.78	47.32	50.66
H_2O	[b] 1.00					
$(Al, Fe)_2O_3$	.18	2.46	2.94	1.40	.76	.48
	99.65	94.24	93.25	97.55	97.03	98.94

[a] Calculated to satisfy bases.

[b] Loss on ignition, minus CO_2.

G. From Placer County deposits, Cal. Analysis by R. C. Wells.

H, I. From Red Slide deposits, Sonoma County, Cal. Analyses by W. C. Wheeler.

J, K. From Larious Creek, San Benito County, Cal. Analyses by W. B. Hicks. See Gale, loc. cit.

	G	H	I	J	K
SiO_2	0.2	3.66	10.21	11.08	0.81
MgO	47.3	44.90	41.06	41.38	46.67
CaO	None.	.20	.59	.60	1.04
CO_2	51.6	49.20	44.76	45.26	50.60
H_2O	.6	.76	1.78	Undet.	Undet.
Al_2O_3		.75	.31	.55	None.
Fe_2O_3		.44	.74	.61	.52
	99.7	99.91	99.45	99.48	99.64

HYDROMAGNESITE.

From San Benito, Cal. Analysis by W. B. Hicks.

MgO	41.60
CO_2	34.89
SiO_2	2.50
Al_2O_3	.13
Fe_2O_3	.44
CaO	.34
Ignition[a]	20.10
	100.00

HYDROGIOBERTITE.

A spring deposit in and upon shale, collected by G. A. Waring near Phillips Springs, Chiles Valley, Napa County, Cal. Analyzed by R. C. Wells, and described by him in Am. Jour. Sci., ser. 4, vol. 30, p. 189. The insoluble portion is mainly shale. The ratios between MgO, CO_2 and H_2O are those of hydrogiobertite. Two analyses were made.

	A	B
Insoluble in HCl	25.37	14.93
MgO	31.81	36.40
CO_2	18.07	23.71
H_2O	19.94	20.81
CaO	2.57	1.84
$(Al, Fe)_2O_3$	1.88	1.06
	99.64	98.75

SMITHSONITE.

From Marion County, Ark. Bright yellow variety, known locally as "turkey-fat ore." Analysis by H. N. Stokes.

SiO_2	0.06
ZnO	64.12
CdO	.63
CdS	.25
CO_2	34.68
CuO	Trace.
FeO	.14
CaO	.38
	100.26

TENGERITE.

From Baringer Hill, Llano County, Tex. Received from W. E. Hidden. Approximate analysis, on insufficient material, by W. F. Hillebrand.

Y_2O_3	40.8
Ce_2O_3	7.0
Fe_2O_3	4.0
GlO	9.7
CO_2	19.6
H_2O-	3.2
H_2O+	14.1
SiO_2	.4
	98.8

Magnesia, alkalies, etc., undetermined.

---

[a] Difference between CO_2 and CO_2+H_2O.

BASTNÄSITE.

Associated with the tysonite of Cheyenne Mountain, near Pikes Peak, Colo. Sp. gr. 5.12 at 27°. Analyzed by W. F. Hillebrand and described by him in Bull. 167.

Ce_2O_3	[a]37.71
La_2O_3 group	36.29
Fe_2O_3	.22
CO_2	20.03
Na_2O	.18
K_2O, Li_2O	Traces.
H_2O	.08
F	7.83
	102.34
O equivalent to F	3.30
	99.04

URAO.

Deposited from the waters of Owens Lake, Cal. Analyses by T. M. Chatard. Described by Chatard in Bull. 60. Five samples analyzed, as follows:

A. The best material. Sp. gr., 2.1473 at 21.7°.
B. Crude urao.
C. Urao deposited upon a grass root.
D. From a small lagoon.
E. From a vat dug on the beach of Owens Lake.

	A	B	C	D	E
Insoluble, inorganic	0.02	0.22	2.92	0.40	4.10
Insoluble, organic			.14	.12	.27
SiO_2		.10	.05	.09	.04
Cl	.19	1.57	2.73	.21	1.83
SO_3	.70	.79	.76	.63	.84
CO_2	38.13	37.00	35.24	37.50	35.10
Na_2O	41.00	41.26	40.22	40.08	39.36
K_2O				Trace.	
CaO				.06	
MgO				.02	
H_2O	20.07	19.62	18.31	19.94	18.58
	100.11	100.56	100.37	99.05	100.12
O equivalent to Cl	.04	.35	.61	.05	.41
	100.07	100.21	99.76	99.00	99.71

VII. SILICATES.

PETALITE.

From Peru, Maine, associated with spodumene. Analysis by F. W. Clarke.

Ignition	1.03
SiO_2	77.29
Al_2O_3	16.95
Fe_2O_3	Trace.
MnO	Trace.
Li_2O	2.62
Na_2O	2.39
K_2O	Trace.
	100.28

---

[a] Includes 0.10 ThO_2.

ORTHOCLASE AND MICROCLINE.

A. Orthoclase from Silver City, Idaho. Occurs as a gangue mineral. Partial analysis by W. F. Hillebrand.

B. Orthoclase from Mitchell County, N. C. Large cleavage mass. Analysis by E. T. Allen. See Am. Jour. Sci., ser. 4, vol. 19, p. 119.

C. Feldspar crystal from the nevadite of Chalk Mountain, Summit County, Colo. Analysis by W. F. Hillebrand.

D. Pink orthoclase crystals, from gray porphyry, Johnson Gulch, near Leadville, Colo. Described by Cross in Mon. XII, Appendix A. Analysis by W. F. Hillebrand.

E. Feldspar separated from gabbro. East side of North Fowl Lake, Minn. Analysis by W. F. Hillebrand.

F. Feldspar from the elæolite syenite of Litchfield, Maine. Described by Bayley in Bull. 150, p. 201. Analysis by W. H. Melville.

	A	B	C	.D	E	F
SiO_2	66.28	65.49	65.04	62.22	62.71	65.14
TiO_2					Trace.	
Al_2O_3	17.93	17.98	20.40	20.33	19.20	18.19
Fe_2O_3		.36			1.08	
FeO					.93	.25
MnO					Trace.	
CaO		.42	.79	2.95	.44	.33
SrO					Trace.	
MgO		None.	None.		.81	.16
Na_2O	.25	2.29	4.11	3.45	2.96	1.68
K_2O	15.12	12.95	9.74	8.31	10.41	14.14
Li_2O			Trace.		None.	
H_2O-		.51	.29	1.90	.23	.17
H_2O+					.92	
	99.58	100.00	100.37	99.16	99.69	100.06

G. Flesh-colored microcline from the pegmatite of Jones Falls, Baltimore, Md.

H. Greenish microcline, same locality as G. G and H described by S. L. Powell in Johns Hopkins Univ. Circular, vol. 12, p. 49. Analyses by W. F. Hillebrand.

I. Anorthoclase from the elæolite syenite of Peaked Butte, Crazy Mountains, Mont. See Wolff and Tarr in Bull. Mus. Comp. Zool. Harvard Coll., vol. 16, No. 12, 1893. Analysis by W. F. Hillebrand.

J. Anorthoclase from red soda granite, Pigeon Point, Minn. Described by Bayley in Bulletin 109. Analysis by J. E. Whitfield.

K. Anorthoclase from keratophyre, Marblehead Neck, Mass. Described by Sears, Bull. Mus. Comp. Zool. Harvard Coll., vol. 16, No. 9, 1893. Analysis by T. M. Chatard.

	G	H	I	J	K
SiO_2	65.06	68.48	62.31	65.00	65.66
Al_2O_3	18.41	16.11	22.63	18.22	20.05
Fe_2O_3	Trace.	.20		2.64	Trace.
FeO		.17			Trace.
MnO					.13
MgO	.04	.03		.06	.18
CaO	.26	.23	.63	1.06	.67
SrO	Trace.	Trace.	.57		
BaO	.13	.05	.77		
K_2O	14.30	12.90	4.79	4.18	6.56
Na_2O	1.60	1.27	7.68	8.40	6.98
Li_2O	Trace.	Trace.			
H_2O-	.04	.06	.16	.46	.04
H_2O+	.26	.26	.72		.37
	100.10	99.85	100.26	100.02	100.64

ALBITE.

A. From feldspathic schist, central shaft of the Hoosac Tunnel, Berkshire County, Mass. Described by Wolff in Mon. XXIII, pp. 60–187. Analysis by R. B. Riggs.

B, C. From the porphyritic mica schist of Greylock Mountain, Mass. Described by Wolff, loc. cit. Analyses by R. B. Riggs.

D. From the elæolite syenite of Litchfield, Maine. Described by Bayley in Bull. 150, p. 201. Sp. gr., 2.622. Analysis by W. H. Melville.

E. From the pegmatite of Jones Falls, Baltimore, Md. Described by S. L. Powell in Johns Hopkins Univ. Circular, vol. 12, p. 49. Analysis by W. F. Hillebrand.

F. From Amelia County, Va. Analysis by E. T. Allen.

G. From Mitchell County, N. C. Analysis by Allen.

	A	B	C	D	E	F	G
SiO_2	69.69	68.08	67.83	68.28	63.72	68.22	66.03
Al_2O_3	18.60	20.11	19.92	19.62	22.26	19.06	20.91
Fe_2O_3						.15	.18
FeO				.23			
MgO	.20	(?)	(?)	.09	.06		
CaO	Trace.	Trace.	Trace.	.31	3.58	.40	2.00
SrO					Trace.		
Na_2O	10.28	11.00	11.65	10.81	8.98	11.47	9.97
K_2O	.40	.36	.25	.39	.76	.20	.70
Li_2O					Trace.		
MnO		Trace.	Trace.				
H_2O-	.42	.31	.12	.09	.09	.69	.59
H_2O+					.43		
	99.59	99.86	99.77	99.82	99.88	100.19	100.38

ANORTHITE.

A. From Raymond, Maine. Associated with idocrase, garnet, pyroxene, and scapolite. Analysis by W. H. Melville.

B. From Phippsburg, Maine. Occurrence similar to A. Incomplete analysis by George Steiger.

C. Separated from "hyperite changing to diorite," near Whitaker's ore pit, Wilmington, Del. Described by Chester in Bull. 59. Analysis by R. B. Riggs. Sp. gr., 2.592 to 2.749.

	A	B	C
SiO_2	43.13	45.62	44.09
Al_2O_3	30.95	35.29	35.41
Fe_2O_3	1.04		.51
FeO	Trace.		
MnO	Trace.		
CaO	19.71	17.31	18.47
MgO	.31		None.
K_2O	1.29		.19
Na_2O	.69		.99
Li_2O	Trace.		
H_2O-	.22		.35
H_2O+	2.80		
	100.14	98.22	100.01

SODA-LIME FELDSPARS.

A. Transparent oligoclase, from Bakersville, N. C. Analysis by F. W. Clarke.

B. Feldspar separated from porphyrite; Sugar Loaf, northwest of Elk Mountain, Tenmile district, Summit County, Colo. Much altered. Analysis by W. F. Hillebrand.

C. Feldspar separated from andesite; mesa northwest of Parkdale, Colo. Analysis by W. F. Hillebrand.

D. Feldspar separated from gabbro; Brandywine Creek, Wilmington, Del. Sp. gr., 2.592 to 2.877. Described by Chester in Bull. 59. Analysis by R. B. Riggs.

E. Feldspar from hypersthene gabbro, Wilmington, Del. Sp. gr., 2.592 to 2.780. Described by Chester, analysis by Riggs.

F. Feldspar separated from the gabbro of Ashland County, Wis. Analysis by W. F. Hillebrand.

G. Feldspar separated from diabase; near southeast corner of sec. 13, T. 47 N., R. 46 W., Michigan. Described by Van Hise in Mon. XIX. Analysis by T. M. Chatard.

	A	B	C	D	E	F	G
SiO_2	62.92	62.96	63.02	70.37	51.44	53.30	51.18
TiO_2						Trace.	
Al_2O_3	25.32	21.51	23.06	18.36	30.05	29.03	27.00
Fe_2O_3	Trace.			.58	.96	.55	3.19
FeO		.32		Undet.		.23	Undet.
CaO	4.03	4.00	3.39	5.08	13.19	11.40	11.70
SrO		.13	Trace.			Trace.	
BaO						Trace.	
MgO		.30	Trace.	.04	Trace.	.13	1.92
MnO	Trace.			Trace.		None.	.17
K_2O	.96	1.60	3.92	.63	.21	.40	.41
Na_2O	6.18	6.15	6.76	4.32	4.07	4.87	3.48
Li_2O		Trace.	None.			None.	
P_2O_5						Trace.	
H_2O	.25	2.78	.26	.45	.35	.23	1.19
	99.66	99.75	100.40	99.83	100.27	100.14	100.24

H, I. Feldspars separated from olivine diabase; NE. ¼ sec. 13, T. 45 N., R. 1 W., Wisconsin. See Van Hise, Mon. XIX. Analyses by T. M. Chatard.

J. Feldspar from gabbro; southern half of sec. 14, T. 44 N., R. 4 W., Wisconsin. See Van Hise, loc. cit. Analysis by T. M. Chatard.

The following feldspars were separated from Minnesota gabbros for W. S. Bayley and analyzed by W. F. Hillebrand:

K. From average gabbro, south quarter post of sec. 35, T. 61 N., R. 12 W.

L. From gabbro, NW. ¼ SE. ¼ sec. 23, T. 62 N., R. 10.

M. From gabbro, center of sec. 25, T. 64 N., R. 8.

N. From gabbro, Duluth & Iron Range Railroad.

O, P. Two feldspars separated from the amphibolite of Palmer Center, Mass. Analyses by W. F. Hillebrand. Specific gravity of O, 2.667 at 24°; of P, 2.677 at 22°. In O calculation gives about 7.4 and in P 7.6 per cent of admixed quartz.

	H	I	J	K	L	M	N	O	P
SiO_2	61.65	56.15	51.99	51.89	52.50	52.61	53.45	62.91	60.90
Al_2O_3	19.91	26.05	29.32	29.68	30.15	29.80	29.77	23.37	24.97
Fe_2O_3	2.28	1.98	1.23	.32	.47	.57	.33	Trace.	Trace.
FeO	Undet.	Undet.		.37	.15	.23	.15		
MnO	Trace.	.13	Trace.			Trace.			
CaO	4.12	8.70	12.60	12.62	12.82	12.25	11.33	5.83	7.85
MgO	.61	.54	.63	.38	.10	.20	.11		
Na_2O	4.74	4.79	2.91	3.87	3.72	3.80	4.33	7.78	6.26
K_2O	5.72	1.56	.28	.50	.53	.53	.68	.20	.16
H_2O-	.95	.13	.03	.07	.25	.29	.23	.42	.48
H_2O+		.64	.54	.39					
TiO_2					Trace.	Trace.	Trace.	Trace.	Trace.
	99.98	100.67	99.53	100.09	100.69	100.28	100.38	100.51	100.62

LEUCITE.

From Mount Vesuvius. A fine crystal. Analysis by George Steiger.

SiO_2	55.40
Al_2O_3	23.69
CaO	.16
K_2O	19.54
Na_2O	1.25
H_2O	.24
	100.28

ENSTATITE.

A. Enstatite from Granville. Mass. Slightly altered. Described by Emerson in Mon. XXIX. Analysis by W. F. Hillebrand.

B. Enstatite separated from the San Emigdio meteorite, found in San Bernardino County, Cal. Analysis by J. E. Whitfield.

C. White, fibrous mineral, near enstatite, from seams in chrysolite rock, Corundum Hill, N. C.

D. Altered enstatite, Corundum Hill. Analyses C and D by T. M. Chatard. (See Bull. 42.) Sp. gr., 2.872.

E. Bronzite separated from the websterite of Hebbville, Md. Described by Williams in Am. Geologist, vol. 6, p. 35. Analysis by T. M. Chatard.

	A	B	C	D	E
SiO_2	54.04	54.42	56.39	56.58	54.53
TiO_2	None.	....	None.	None.	Undet.
Al_2O_3	.52	....	2.31	1.74	1.93
Fe_2O_3	1.51	....	.16	1.89	1.70
FeO	3.90	14.03	1.96	3.67	8.92
MnO	.11	....	....	.21	.28
NiO	.23	....	....	....	....
Cr_2O_3	.14	....	....	.24	.30
MgO	34.40	29.11	34.57	30.34	29.51
CaO	None.	2.46	.04	.59	2.25
Alkalies	.08	....	....	.17	....
P_2O_5	None.	....	....	....	Trace.
CO_2	1.32	....	....	....	....
H_2O-	.70	....	4.32	4.55	1.14
H_2O+	3.07	....			
	100.02	100.02	99.75	99.98	100.56

HYPERSTHENE.

A. From the basalt of Mount Thielsen, Oreg. Incomplete analysis by T. M. Chatard.

B. From gabbro, SE. ¼ sec. 20, T. 65 N., R. 4 W., Minnesota. Described by Bayley in Jour. Geology, vol. 3, p. 1. Analysis by E. A. Schneider.

C. From the augite andesite of the Tokajer-Berg, Hungary. Analysis by W. F. Hillebrand. Sp. gr., 3.495 at 25°.

D, E, F. Three specimens separated from the hypersthene andesite of the Buffalo Peaks, Colo. Described by Cross in Bull. 1. Analyses by W. F. Hillebrand. In D and E alkalies were disregarded. In E and F all the iron is given as FeO. Sp. gr., of F, 3.307 at 23°.

	A	B	C	D	E	F
SiO_2	53.31	48.44	51.44	51.70	51.16	50.04
TiO_2		Undet.	.73			
Al_2O_3	5.99	7.91	.60	1.72	2.15	2.91
Fe_2O_3	13.43	.33	2.28	.30	18.36	17.81
FeO		20.88	20.77	18.00		
MnO		.92	.88	.36	.36	.12
MgO	21.69	19.35	19.93	25.09	24.25	21.74
CaO	3.69	1.44	3.80	2.87	3.81	6.70
Na_2O						.27
H_2O-		.08				
H_2O+		None.				
	98.11	99.35	100.43	100.04	100.09	99.59

PYROXENE.

A. Diopside separated from the websterite of Hebbville, Md. Described by G. H. Williams, Am. Geologist, vol. 6, p. 35. Analysis by T. M. Chatard.

B. Diopside from the leucite rocks of the Leucite Hills, Wyo. Described by Cross, Am. Jour. Sci., 4th ser., vol. 4, p. 115. Sp. gr., 3.290 at 20°. Analysis by W. F. Hillebrand.

C. Pyroxene from Moriah, N. Y. The source of associated serpentine. Analysis by Charles Catlett.

D. Dark-gray pyroxene, Montville, N. J. The source of associated serpentine. Analysis by Charles Catlett.

E. Diallage from the gabbro of Ashland County, Wis. Analysis by W. F. Hillebrand.

F. Pyroxene from orthoclase gabbro, 1 mile northeast of Haystack Mountain, Livingston quadrangle, Montana. Described by W. H. Emmons, Jour. Geology, vol. 16, p. 193. Analysis by G. Steiger.

	A	B	C	D	E	F
SiO_2	51.80	50.86	55.36	51.45	49.80	50.95
TiO_2	.13	3.03			1.29	1.42
Al_2O_3	2.21		.22	2.94	2.86	2.72
Cr_2O_3	.51		None.			
Fe_2O_3	1.29	1.19	.18	1.06	2.48	1.70
FeO	3.50	1.82	.57	.96	10.82	13.86
MnO	Trace.	.03	Trace.	Trace.	.37	.26
MgO	17.76	17.42	19.53	18.43	15.33	15.58
CaO	20.99	23.32	24.48	24.02	16.50	11.39
Na_2O	Undet.	.76			.51	.31
K_2O	Undet.	.42			.12	
P_2O_5	Trace.				Trace.	
H_2O	.65	.31		1.03	.33	1.80
	98.84	99.16	100.34	99.94	100.41	99.99

G. Augite from nepheline basalt, Black Mountain, Uvalde quadrangle, Texas. Violet colored. Analysis by W. F. Hillebrand.

H. Augite from dolerite dike, near Valmont, Colo. See Cross, Mon. XXVII. Analysis by L. G. Eakins.

I. Augite from tinguaite, Two Buttes, Colo. Sp. gr., 3.43 at 28°. Analysis by W. F. Hillebrand.

J. Pyroxene from syenitic lamprophyre, Two Buttes, Colo. Sp. gr., 3.45 at 25°. Analysis by W. F. Hillebrand.

K. Augite from granite, north end of Blue Mountains, Silver Cliff, Colo. Sp. gr., 3.225 at 18°. Analysis by L. G. Eakins.

L. Augite from the Golden King dike, Silver Cliff, Colo. Sp. gr., 3.281 at 13°. Analysis by L. G. Eakins.

M. Pyroxene from norite, dike east of Sugar Loaf, Boulder County, Colo. Analysis by L. G. Eakins.

	G	H	I	J	K	L	M
SiO_2	45.23	49.10	47.54	51.27	48.72	54.87	47.32
TiO_2	4.28		3.00	.70			
ZrO_2			None.	None.			
Al_2O_3	7.73	7.95	4.14	3.05	9.27	6.34	6.37
Cr_2O_3			Trace?	None.			
Fe_2O_3	2.95		5.64	3.08	3.77	2.88	2.56
FeO	4.07	8.30	6.42	4.34	6.34	4.61	14.40
MnO	.07		.36	.28	.34	.14	
MgO	12.25	12.37	10.05	14.21	14.67	14.47	13.43
CaO	23.37	22.54	21.57	22.58	16.79	15.87	16.08
Na_2O	.47	Trace.	1.38	.67	.19	.28	
K_2O	.12	Trace.	.12	.06			
Li_2O	Trace.		Trace.				
BaO	None.		None.	None.			
SrO	None.		None.	None.			
NiO	.05		Trace.	.03			
P_2O_5	None.						
H_2O	.37		Undet.	Undet.	.18	.31	
	100.96	100.26	100.22	100.27	100.27	99.77	100.16

N. Pyroxene from Italian Mountain, Gunnison County, Colo. Associated with idocrase, scapolite, garnet, epidote, etc. Analysis by L. G. Eakins. Sp. gr., 3.312 at 16.7°.

O. Augite from basalt, 6 miles northeast of Grants, Mount Taylor region, New Mexico. Analysis by T. M. Chatard.

P. Pyroxene from peridotite, east of Fort Ellis, Mont. Partial analysis by F. W. Clarke.

Q. Pyroxene from basalt, east side of Bozeman Creek, 2½ miles southeast of Bozeman, Mont. Described by Merrill, Proc. U. S. Nat. Mus., vol. 17, p. 637. Analysis by L. G. Eakins.

	N	O	P	Q
SiO_2	47.53	47.06	51.95	52.50
TiO_2		1.82		
Al_2O_3	9.88	7.77	4.21	2.26
Cr_2O_3		Trace.		1.07
Fe_2O_3	1.79	1.30		2.05
FeO	.91	8.15	5.90	2.47
MgO	Trace.	.20	Undet.	Trace.
NiO, CoO		Trace.		
MgO	14.43	13.52	13.81	17.11
CaO	25.46	19.33	23.32	21.70
Na_2O	Trace.	.33		.35
K_2O		.11		.07
P_2O_5		.06		
H_2O	.30	.20	Undet.	.64
	100.30	99.85	99.19	100.22

R. Jeffersonite from Franklin Furnace, N. J. Analyzed by W. F. Hillebrand and described by him in Bull. 167.

S. Jeffersonite, Parker mine, Franklin Furnace, N. J. Collected by C. Palache. Analysis by G. Steiger.

T. Manganese pyroxene, Sterling Hill, N. J. Collected by C. Palache. Analysis by W. T. Schaller.

	R	S	T
SiO_2	51.70	49.03	49.80
Al_2O_3	.36	.86	.26
Fe_2O_3	.37	4.22	1.46
FeO	....	3.95	1.61
MnO	7.43	7.91	9.69
MgO	12.57	5.81	12.35
CaO	23.68	19.88	21.07
ZnO	3.31	7.14	Trace.
Na_2O	.12	....	.09
K_2O	Trace.	....	....
H_2O-	.65	.60	1.55
H_2O+		.70	1.31
CO_2	....	....	.43
F	....	....	.31
	100.19	100.10	99.93
Less O	....	....	.13
	....	....	99.80

ACMITE.

A. From Magnet Grove, Ark. Analysis by G. Steiger.[1]

B. Vanadiferous ægirite.

C. Vanadiferous ægirite-augite. About 43 per cent acmite and 57 per cent diopside.

Minerals B, C, are from Rainy Creek mining district, 7 miles north of Libby, Mont. Described by E. S. Larsen and W. F. Hunt in Am. Jour. Sci., 4th ser., vol. 36, p. 289. Analyses by Hunt.

	A	B	C
SiO_2	50.45	51.91	53.32
Al_2O_3	2.76	.38	1.40
Fe_2O_3	23.42	21.79	12.38
FeO	5.26	1.48	3.70
MnO	.10	.58	.45
MgO	1.48	3.08	7.01
CaO	5.92	5.53	12.18
Na_2O	9.84	10.46	6.26
K_2O	.24	.22	.26
H_2O-	.15	.06	.07
H_2O+	.40	None.	.13
TiO_2	....	.91	.38
V_2O_3	....	3.98	2.86
CO_2	....	Trace.	....
S	....	.13	....
Cr_2O_3	....	....	Trace.
	100.02	100.41	100.40

JADEITE.

The following analyses of jadeite, all by F. W. Clarke, were discussed by Clarke and Merrill in the Proceedings of the United States National Museum for 1888. They all represent worked material.

A. Light-colored bead mottled with emerald green, from State of Oaxaca, Mexico. Sp. gr., 3.007, determined by William Hallock.

B. Carved bead, light green, from Zaachita, Oaxaca. Sp. gr., 3.190, Hallock.

C. Fragment from Sardinal, Costa Rica; pale green, translucent. Sp. gr., 3.32, Clarke.

D. Fragment from Culebra, Costa Rica; light green, granular, opaque; quite impure. Sp. gr., 3.27, Clarke.

---

[1] Supplementary determination by H. S. Washington gave 0.90 TiO_2 and 0.08 ZrO_2. These lower the Al_2O_3 to 1.78 per cent.

	A	B	C	D
SiO_2	58.88	58.18	59.18	58.33
Al_2O_3	25.93	23.53	22.96	21.63
Cr_2O_3	.12	......	......	......
Fe_2O_3	.24	1.67	1.87	1.71
FeO				.73
MgO	.36	1.72	.67	3.09
CaO	.40	2.35	1.52	4.92
Na_2O	11.64	11.81	12.71	8.13
K_2O	.63	.77	Trace.	.22
Ignition	1.81	.53	.90	.93
	100.01	100.56	99.81	99.69

WOLLASTONITE.

A. From Diana, N. Y. Partial analysis by E. A. Schneider.

B. From Empire copper deposits, near Mackay, Idaho. Analysis by W. C. Wheeler. Sp. gr., 2.933.

	A	B
SiO_2	50.05	50.47
Al_2O_3	1.13	.45
Fe_2O_3		.27
CaO	47.10	45.99
MgO	.09	1.17
H_2O	.45	.09
CO_2	......	.69
	98.82	99.13

PECTOLITE.

A. Stone hammer, at first thought to be jade, collected among the Eskimo of Point Barrow, Alaska. Analyzed by F. W. Clarke and described by him in Bull. 9. Pale apple green, highly polished, tough and compact. Sp. gr., 2.873.

B. Radiated pectolite, Bergen Hill, N. J. Analysis by E. A. Schneider.

C. Another sample from Bergen Hill. Analysis by G. Steiger.

D. From the Spence mine, Waldo, Oreg. Analysis by R. C. Wells.

	A	B	C	D
SiO_2	53.94	53.11	53.34	54.34
Al_2O_3	.58	.40	.33	.58
Fe_2O_3				......
MnO	......	.81	.45	......
CaO	32.21	33.88	33.23	30.67
MgO	1.43	......	......	.03
Na_2O	8.57	8.62	9.11	7.89
K_2O	......	......	......	.59
CO_2	......	......	.67	......
H_2O-	4.09	.04	.27	4.15
H_2O+		3.00	2.70	
	100.82	99.86	100.10	98.25

AMPHIBOLE.

A. Tremolite, pseudomorphous after sahlite; northeast slope of Canaan Mountain, Conn. Analysis by W. F. Hillebrand.

B. Tremolite, found in the serpentine of Easton, Pa. Analysis by L. G. Eakins.

C. Actinolite (?), Corundum Hill, N. C. Sp. gr., 3.062. Analyzed by T. M. Chatard and described by him in Bull. 42.

D. Nephrite, New Zealand. Fragment from a dark-green bowlder. Analysis by F. W. Clarke.

E. Nephrite, Robenhausen, Lake Pfäffikon, Switzerland. Part of a green, compact, highly polished jade implement. Sp. gr., 3.015; determined by William Hallock. Analysis by F. W. Clarke.

	A	B	C	D	E
SiO_2	57.97	58.27	55.23	56.73	56.87
TiO_2	None.	......	None.	......	......
Al_2O_3	.09	.33	3.04	3.22	1.50
Cr_2O_3	......	......	.19	......	......
Fe_2O_3	.11	Trace.	1.88	5.96	6.33
FeO	.18	......	2.51		
MnO	Trace.	.08	.26	Trace.	Trace.
NiO, CoO	......	......	Trace.	......	......
CaO	15.05	11.90	13.36	13.24	13.45
SrO	Trace.	......	......	......	......
MgO	22.45	25.93	22.31	19.42	21.06
K_2O	.12	.42	.58	Undet.	Undet.
Na_2O	.20	1.25		Undet.	Undet.
H_2O-	.03	1.22	.04	.83	.63
H_2O+	2.57		.52		
CO_2	1.69	......	......	......	......
	100.46	99.40	99.92	99.40	99.84

F. Dark-green nephrite implement, from the Eskimo of Point Barrow, Alaska. Sp. gr., 3.012. Analysis by F. W. Clarke.

G. Nephrite adze, Point Barrow. Nearly black, with grayish-green patches. Sp. gr., 2.922, Hallock. Analysis by F. W. Clarke.

H. Nephrite adze, Cape Prince of Wales, Alaska. Dark green, laminated in two shades, opaque. Sp. gr., 2.989, Hallock. Analysis by F. W. Clarke.

I. Worked nephrite, St. Michael, Alaska. Dull apple green, fairly uniform in tint, semitranslucent at edges. Sp. gr., 3.006, Hallock. Analysis by F. W. Clarke.

J. Jade implement, Diomede Island, Alaska. Dark green, laminated in two shades, opaque. Sp. gr., 3.010, Hallock. Analysis by F. W. Clarke.

	F	G	H	I	J
SiO_2	57.01	57.11	56.01	56.12	56.08
Al_2O_3	.42	2.57	1.98	.63	1.01
FeO	6.95	5.15	6.34	7.45	7.67
CaO	12.75	11.54	12.54	12.72	13.35
MgO	21.36	21.38	21.57	20.92	19.96
MnO	......	Trace.	Trace.	Trace.	Trace.
Ignition	1.41	2.06	1.91	1.42	2.03
Alkalies	Undet.	Undet.	Undet.	Undet.	Undet.
	99.90	99.81	100.35	99.26	100.10

K, L, M, N. Four samples of nephrite, found in place by Lieut. Stoney, U. S. Navy, near the Kowak River, Alaska. K, greenish gray, splintery-lamellar; L, like K but more granular. M, paler, nearly white, closer grained. N, brownish, highly foliated. Analyses by F. W. Clarke. Ferrous iron determinations by R. B. Riggs.

O. Nephrite from Jordansmuhl, Silesia; analysis by George Steiger, typical material from an old locality. For details concerning nephrites D to N, see the memoir by Clarke and Merrill in Proc. U. S. Nat. Mus. for 1888.

	K	L	M	N	O
SiO_2	58.11	55.87	56.85	57.38	56.39
TiO_2					None.
Al_2O_3	.24	2.07	.88	.19	1.63
Fe_2O_3	5.44	5.79	4.33	4.43	1.72
FeO	.38	.38	1.45	1.25	3.70
MnO	Trace.	Trace.	Trace.	Trace.	.26
NiO					.13
CaO	12.01	12.43	13.09	12.14	7.92
MgO	21.97	21.62	21.56	22.71	24.63
Alkalies	Undet.	Undet.	Undet.	Undet.	None.
P_2O_5					Trace.
H_2O-	1.78	1.38	1.76	1.73	.65
H_2O+					3.42
	99.93	99.54	99.92	99.83	100.45

P. Brown hornblende, Pierrepont, N. Y. Analysis by T. M. Chatard.

Q. Hornblende separated from gabbro, east shaft of waterworks extension, Washington, D. C. Analysis by R. B. Riggs.

R. Amphibole from the serpentine of Montville, N. J. Analysis by L. G. Eakins.

S. Hornblende separation, gedrite, from south of soapstone quarry, Warwick, Mass. Analysis by E. A. Schneider.

T. Hornblende from amphibolite dike, Palmer Center, Mass. Sp. gr., 3.220 at 31.5°. Analysis by W. F. Hillebrand.

U. Hornblende from amphibolite bed, same locality and analyst. Sp. gr., 3.217 at 29°.

	P	Q	R	S	T	U
SiO_2	56.44	52.42	43.31	47.86	43.11	44.09
TiO_2	.11			[a].63	1.32	1.73
Al_2O_3	1.77	3.15	17.41	14.09	11.10	10.68
V_2O_3					.07	Undet.
Cr_2O_3					Trace.	Trace.
Fe_2O_3	.84	3.60	.71	.33	4.97	2.72
FeO	.73	8.36	.59	13.41	13.04	12.96
MnO	.11	.11	.14	.14	.43	.32
NiO					Trace.	Trace.
CaO	11.83	14.33	12.84	.57	11.76	11.58
MgO	22.98	15.85	19.39	19.89	9.35	10.75
K_2O	.75	.12	1.36	.06	1.27	.88
Na_2O	2.13	1.16	2.23	.93	1.18	1.19
H_2O-	.05	1.25	1.17	None.	.16	.21
H_2O+	2.41			2.46	1.92	1.91
P_2O_5	Trace.			.05	.10	.10
	100.15	100.35	99.15	100.42	99.78	99.12

[a] Admixed rutile.

V. Hornblende near barkevikite. Separated from the sodalite syenite of Square Butte, Highwood Mountains, Mont. Described by Lindgren in Am. Jour. Sci., 3d ser., vol. 45, p. 286. Analysis by W. H. Melville.

W. Amphibole separated from quartz diorite, south of Table Mountain, on ridge between Butte and Plumas counties, Cal. Described by Turner in 17th Ann., pt. 1, p. 521. Analysis by William Valentine. Chromium determination by Hillebrand.

X. Amphibole separated from amphibole gabbro, Beaver Creek, Big Trees quadrangle, Cal. Analysis by William Valentine. See Bull. 168, p. 206.

Y. Amphibole separated from quartz monzonite, Tioga road, southeast of Mount Hoffman, Mariposa County, Cal. Sp. gr., 3.203 at 21.5°. Analysis by W. F. Hillebrand. See Bull. 168, p. 208.

Z. Amphibole separated from the granite of Butte, Mont. Incomplete analysis for lack of material. Analysis by H. N. Stokes.

	V	W	X	Y	Z
SiO_2	38.41	50.08	46.08	47.49	45.73
TiO_2		.76	.77	1.21	1.43
Al_2O_3	17.65	7.97	10.56	7.07	6.77
V_2O_3				.04	
Cr_2O_3		.16		None.	None.
Fe_2O_3	3.75	2.69	2.81	4.88	4.94
FeO	21.75	6.71	8.30	10.69	10.39
MnO	.15	.49	.15	.51	.54
NiO	Trace.			.02	
CaO	10.52	11.21	12.64	11.92	11.25
MgO	2.54	16.31	14.40	13.06	12.32
Na_2O	2.95	1.22	1.62	.75	.77
K_2O	1.95	.46	.34	.49	1.22
Li_2O			None.	Trace.	Trace.
H_2O-			.17		.49
H_2O+	.24	1.40	1.97	1.86	2.29
P_2O_5		Trace.	.18	None.	.35
F		Undet.	None.	.06	.28
	99.91	99.46	99.99	100.05	98.77
O equivalent to F				.02	.12
				100.03	98.65

BERYL.

A. White beryl from the tin mine at Winslow, Maine. Opaque, milky. Sp. gr., 2.707 at 27°. Analysis by W. F. Hillebrand.

B. Green beryl from near Home post office in eastern Tennessee. Analysis by F. W. Clarke.

C. Pink beryl, from Oak Grove, San Diego County, Cal. Analysis by W. T. Schaller. Sp. gr., 2.753.

	A	B	C
SiO_2	65.21	65.39	62.95
Al_2O_3	18.50	[a] 19.10	17.79
GlO	13.03	13.35	11.40
Fe_2O_3	.33		
FeO			
Li_2O	.16		.99
Na_2O	.87		2.53
K_2O	.14		None.
Cs_2O			1.60
MgO	.09		
TiO_2	Trace.		
H_2O	1.80	1.76	2.49
	100.13	99.60	99.75

[a] Includes a little Fe_2O_3.

NEPHELITE.

A. Elæolite from Litchfield, Maine. Dark-gray cleavable masses, of greasy luster. Described by F. W. Clarke in Bull. 42.

B. Another sample from Litchfield. Analysis by George Steiger.

C. Nephelite extracted by solution from the elæolite syenite of Red Hill, N. H. Described by Bayley in Bull. Geol. Soc. America, vol. 3, p. 231. Analysis by W. F. Hillebrand.

	A	B	C
SiO_2	43.74	45.91	45.31
Al_2O_3	34.48	31.14	32.67
Fe_2O_3	....	.34	....
FeO	....	.23	....
MgO	....	....	.16
CaO	Trace.	.33	2.00
Na_2O	16.62	14.60	12.60
K_2O	4.55	5.60	5.70
H_2O-	.86	.47	....
H_2O+		.93	1.56
CO_2	....	.40	....
	100.25	99.95	100.00

CANCRINITE.

All from Litchfield, Maine. See description by Clarke in Bull. 42.

A. Pale yellow, granular.

B. Bright orange-yellow, cleavable, transparent in thin fragments.

C. Dingy pale yellow, otherwise like B.

D. Average yellow sample.

E. Flesh-colored, cleavable mixture of elæolite and cancrinite. Analysis D by George Steiger; the others by F. W. Clarke. CO_2 determinations in A, B, C, E by R. B. Riggs.

	A	B	C	D	E
SiO_2	37.22	36.29	35.83	36.19	38.93
Al_2O_3	28.32	30.12	29.45	29.24	32.52
Fe_2O_3	Trace.	Trace.	Trace.	Trace.	....
MnO	Trace.	Trace.	Trace.	....	Trace.
CaO	4.40	4.27	5.12	4.72	2.47
MgO	.07	....	....	....	None.
Na_2O	19.43	19.56	19.33	19.20	17.02
K_2O	.18	.18	.09	.14	3.23
H_2O	3.86	2.98	3.79	4.15	2.83
CO_2	6.22	6.96	6.50	6.11	2.95
	99.70	100.36	100.11	99.75	99.95

SODALITE.

A. Blue sodalite, from Litchfield, Maine. Analysis by F. W. Clarke. Description in Bull. 42.

B. Blue sodalite, from Ice River, near Kicking Horse Pass, British Columbia. Analysis by George Steiger.

C. Sodalite separated from the sodalite syenite of Square Butte, Highwood Mountains, Mont. See Lindgren in Am. Jour. Sci., 3d ser., vol. 45, p. 286. Sp. gr., 2.265. Analysis by W. H. Melville.

	A	B	C
SiO_2	37.33	39.66	41.56
Al_2O_3	31.87	30.09	29.48
Fe_2O_3	....	.31	....
FeO	....	....	.49
MgO	....	....	.15
CaO	....	.18	.49
Na_2O	24.56	22.60	19.21
K_2O	.10	1.14	.91
H_2O-	1.07	.17	.45
H_2O+		.79	3.73
Cl	6.83	6.12	4.79
	101.76	101.06	101.26
O equivalent to Cl	1.54	1.39	1.08
	100.22	99.67	100.18

ZUNYITE.

From the Zuni mine, Anvil Mountain, near Silverton, Colo. Analyzed by W. F. Hillebrand, and described by him as a new species in Bull. 20. Sp. gr., 2.875 at 15°.

SiO_2	24.33
Fe_2O_3	.20
Al_2O_3	57.88
K_2O	.10
Na_2O	.24
Li_2O	Trace.
H_2O	10.89
P_2O_5	.60
F	5.61
Cl	2.91
	102.76
O equivalent to F and Cl	3.02
	99.74

GARNET.

A. White grossularite, 35 miles east of Selma, Fresno County, Cal. Analysis by George Steiger. Sp. gr., 3.586.

B. Grossularite. Large waterworn pebble, pale green, very compact. At first thought to be jade. From Eltoro, 40 miles south of Los Angeles, Cal. Described by Clarke in Am. Jour. Sci., 3d ser., vol. 50, p. 76. Analysis by Steiger. Sp. gr., 3.485.

C, D, E. Three samples of garnet from Italian Mountain, Gunnison County, Colo. Sp. gr.: A, 3.72 at 16°; B, 3.629 at 23°; C, 3.721 at 17.2°. Analyses by L. G. Eakins.

F. Pyrope from the peridotite dike of Elliott County, Ky. Described by Diller in Bull. 38. Analysis by T. M. Chatard.

G. Garnets from Hawkes's quarry, Goshen, Mass. Almandite. Analysis by Steiger.

	A	B	C	D	E	F	G
SiO_2	38.59	37.54	37.89	39.26	36.88	41.32	37.30
TiO_2	None.	Trace.				.16	.24
Al_2O_3	22.24	22.84	7.90	19.63	10.34	21.21	21.84
Cr_2O_3						.91	
Fe_2O_3	.45	.79	16.43	4.48	17.51	4.21	.98
FeO	.36	.26				7.93	32.62
MnO	.10			Trace.		.34	1.86
CaO	35.97	36.66	35.43	36.61	34.85	4.94	3.19
MgO	.64	.44	.59	Trace.	.43	19.32	2.50
Na_2O	None.	.13	1.10	.16	Trace.	.07	
K_2O	None.		Trace.	Trace.			
H_2O-	.31	1.74	.36	.08	.21	.17	
H_2O+	.80						
P_2O_5		Trace.				None.	
CO_2	.39						
F	.17						
	100.02	100.40	99.70	100.22	100.22	100.58	100.53

H. Spessartite from Amelia Court House, Amelia County, Va. Pale brown, crystalline masses. Analyzed by F. W. Clarke and described in Bull. 60.

I. Spessartite from Llano County, Tex. Yellow, granular. Analyzed by W. H. Melville and described in Bull. 90. FeO could not be separately determined.

J. Spessartite from cavities in rhyolite, Nathrop, Colo. Brilliant crystals. Sp. gr., 4.23 at 18°. Described by Cross in Am. Jour. Sci., 3d ser., vol. 31, p. 432. Analysis by L. G. Eakins.

K. Garnet from the Peacock mining claim, Seven Devils mining district, Idaho. Associated with bornite and powellite. Analyzed by W. H. Melville and described in Bull. 90.

L, M. Two samples andradite from Clifton, Ariz. Analyses by George Steiger.

N. Andradite, from the Jumbo mine, Copper Mountain, Prince of Wales Island, Alaska. Analysis by W. T. Schaller.

	H	I	J	K	L	M	N
SiO_2	35.35	35.93	35.66	38.67	36.26	42.63	35.18
TiO_2		Trace.			None.	None.	
Al_2O_3	20.41	18.08	18.55	10.08	.78	1.53	5.15
Fe_2O_3	2.75	4.60	.32	16.00	32.43	31.41	25.05
FeO	1.75		14.25	.91	.32	.30	.40
MnO	38.70	31.77	29.48		.27	.43	
CaO	.94	8.48	1.15	33.35	29.67	23.37	33.36
BaO		Trace.					
MgO	None.	.69		.77	None.	None.	.09
Na_2O		.17	.21		None.		
K_2O			.27		None.		
CuO				Trace.			
P_2O_5		None.			.06	Trace.	
H_2O-	.27	.03	.44	.06	.13		.42
H_2O+		.36			.44		
	100.17	100.11	100.33	99.84	100.36	99.67	99.65

O, P. Andradite from White Knob, near Mackay, Idaho.

Analyses by Chase Palmer. Two distinct specimens.

Q. Andradite from the Empire mine, Duquesne Camp, Patagonia Mountains, Ariz. Analysis by W. T. Schaller.

R. Andradite from Uncompahgre quadrangle, Colorado. Approximate analysis by Schaller.

	O	P	Q	R
SiO_2	36.92	33.57	37.16	34.30
Al_2O_3	8.75	7.56	3.47	4.46
Fe_2O_3	16.85	20.34	28.11	24.09
FeO	.50	1.24	None.	
MgO	.17	2.10	.51	.52
CaO	33.71	30.20	30.23	31.06
Na_2O	.31			
K_2O	.21			
H_2O-	.21	.30		
H_2O+	.39	.54		
TiO_2	.26	.20		[a] 5.08
CO_2	.95			
P_2O_5	.30	.23		
MnO	.67	.60	Present.	
	100.20	99.88	99.48	99.51

[a] Equivalent to 4.57 Ti_2O_3.

CHRYSOLITE.

A. Transparent green pebbles from near Fort Wingate, N. Mex. Analysis by E. A. Schneider.

B. Transparent olivine from the meteorite of Kiowa County, Kans. Described in Bull. 78. Sp. gr., 3.376 at 23.2°. Analysis by L. G. Eakins.

C. Olivine from the peridotite dike of Elliott County, Ky. Described by Diller in Bull. 38. Analysis by T. M. Chatard.

D. Olivine from the peridotite at Riddles, Oreg. The rock is the matrix of nickel silicates. Described by Diller and Clarke in Bull. 60. Analysis by F. W. Clarke.

E. Olivine from olivine gabbro, west side of Birch Lake, Minn. Described by Bayley, Jour. Geology, vol. 1, p. 688. Analysis by W. F. Hillebrand.

F. Olivine separated from the "hampshirite" of Chester, Mass. Analysis by W. T. Schaller.

G. Olivine from olivine basalt, Mauna Loa, Hawaiian Islands. Collected by R. A. Daly. Analysis by G. Steiger.

	A	B	C	D	E	F	G
SiO_2	41.98	40.70	40.05	42.81	35.58	39.43	40.42
TiO_2	....	....	.07	....	1.22	....	.08
Al_2O_3	....	Trace?	.39	....	.92	....	.50
Cr_2O_3	....	....	.24	.79	Trace.	....	.18
Fe_2O_3	.51	.18	2.36	2.61	33.91	7.83	.15
FeO	5.71	10.79	7.14	7.20			11.44
MnO	.10	.14	.20	....	.35	.12	.10
NiO	.42	.02	....	.26	.20	....	.34
CoO	....	....	Trace.	....		....	....
MgO	51.11	48.02	46.68	45.12	26.86	49.26	47.08
CaO	....	....	1.16	None.	.90	None.	.23
Na_2O	....	....	.08	....	....	....	....
K_2O	....	....	.21	....	....	....	....
H_2O-	.05	....	.14	.57	.11	1.20	....
H_2O+	.23	....	.66		.20	1.49	....
P_2O_5	....	....	.04	....	....	....	....
CO_2	....	....	....	....	....	.77	....
	100.11	99.85	99.42	99.36	100.25	100.10	100.52

HODGKINSONITE.

New species from Franklin Furnace, N. J. Described by C. Palache and W. T. Schaller in Jour. Washington Acad. Sci., vol. 3, p. 474.

Average of three analyses by Schaller.

SiO_2	19.86
MnO	20.08
ZnO	52.93
CaO	.93
MgO	.04
H_2O	5.77
	100.21

WILLEMITE.

In fine needles, from the Tres Hermanas mine, N. Mex. Collected by W. Lindgren. Analysis by G. Steiger. Mineral not quite pure. Contains admixed carbonates.

SiO_2	23.52
$(Fe, Al)_2O_3$	.26
ZnO	65.18
CaO	5.78
CO_2	4.59
H_2O	.57
MnO	None.
	99.90

FRIEDELITE.

From the Taylor mine, Franklin Furnace, N. J. Collected by C. Palache. Analysis by W. T. Schaller.

SiO_2	34.69
FeO	1.45
MnO	48.00
MgO	.98
CaO	.63
ZnO	1.05
H_2O-	1.94
H_2O+	9.08
Cl	3.43
	101.25
Less O	.77
	100.48

MIZZONITE.

From a gulch on the side of Italian Mountain, Gunnison County, Colo. Analysis by L. A. Eakins.

SiO_2	57.55
Al_2O_3	21.53
Fe_2O_3	Trace.
CaO	6.18
K_2O	1.64
Na_2O	7.43
H_2O	3.23
Cl	2.82
	100.38
O equivalent to Cl	.63
	99.75

MELILITE.

Collected by E. S. Larsen near Iron Hill, Uncompahgre quadrangle, Colorado. Analyses by W. T. Schaller.

A. Melilite.

B. Decomposition product of melilite. Regarded by Larsen and Schaller as a definite mineral, and named cevollite.

	A	B
SiO_2	42.07	27.06
TiO_2	.20	Trace.
Al_2O_3	10.30	11.49
Fe_2O_3 (in magnetite)	.50	2.81
FeO	2.18	.17
MgO	4.15	3.84
CaO	35.41	29.27
MnO	.16	....
Na_2O	3.24	2.10
K_2O	Trace.	Trace.
P_2O_5 (in apatite)	.82	....
CO_2 (in calcite)	.90	....
H_2O+	.47	5.13
Insoluble	....	18.05
	100.40	99.92

VESUVIANITE.

A. Finely crystallized material from Italian Mountain, Gunnison County, Colo. Analysis by L. G. Eakins. Sp. gr., 3.394 at 20°.

B. From Nevada, 24 kilometers northeast of Silver Peak. Analysis by George Steiger.

C. Pale green, massive. South Fork of Indian Creek, 12 miles from Happy Camp, Siskiyou County, Cal. Analysis by Steiger.

D. From 35 miles east of Selma, Fresno County, Cal. Green, massive, resembling jade. This variety is known as californite. Analysis by Steiger. Sp. gr., 3.359.

E. From Franklin Furnace, N. J. Collected by C. Palache. Analysis by Steiger. Sp. gr., 3.451.

	A	B	C	D	E
SiO_2	37.11	36.80	35.86	36.55	36.41
TiO_2	....	.66	.10	....	....
Al_2O_3	19.30	17.53	18.35	18.89	17.35
Fe_2O_3	3.31	1.56	1.67	.74	1.86
FeO	....	3.27	.39	.74	
MnO	....	.48	.05	None.	1.75
MgO	3.89	1.23	5.43	2.33	1.38
CaO	36.24	35.00	33.51	35.97	33.21
Na_2O	....	.13	None.	....	.44
K_2O	....		None.	....	.50
H_2O-	.06	.10	.29	.58	.24
H_2O+		1.56	4.18	3.42	3.51
P_2O_5	....	.07	.02	....	....
CO_2	....	.65	None.	.91	....
F	.58	.88	None.	.13	.36
ZnO	....	....	....	....	1.74
CuO	....	....	....	....	1.48
PbO	....	....	....	....	Trace.
	100.49	99.92	99.85	100.26	100.23
Less O	.24	.36	....	.05	.15
	100.25	99.56	....	100.21	100.08

ZOISITE.

A. Zoisite from gabbro, east shaft of waterworks extension, Washington, D. C. Analysis by F. W. Clarke; iron determination by R. B. Riggs.

B. Rose-red zoisite, James's mica mine, Yancey County, N. C. Sp. gr., 3.352 at 27°. Analysis by L. G. Eakins.

C. Saussurite from gabbro, Sacramento River road, 37 miles north of Pit River ferry, Shasta County, Cal. Sp. gr., 3.148. Analysis by F. W. Clarke. See Bull. 9.

D. Saussurite from the Saas Valley, Switzerland. Pale greenish. Sp. gr., 3.37. Analysis by F. W. Clarke; iron determination by R. B. Riggs.

	A	B	C	D
SiO_2	45.12	38.98	42.79	48.29
Al_2O_3	30.53	31.02	29.43	27.65
Fe_2O_3	....	4.15	....	....
FeO	1.90	....	3.65	1.45
MnO	....	.23	....	....
MgO	.42	....	1.40	5.36
CaO	17.34	23.80	18.13	12.95
Na_2O	2.02	....	2.51	3.57
K_2O	1.09	....	....	Trace.
H_2O	.74	2.03	2.42	.54
	99.16	100.21	100.33	99.81

EPIDOTE.

A. Dark-gray brilliant crystals from Phippsburg, Maine. Analyzed by W. F. Hillebrand and described in Bull. 167.

B, C. Epidote from Italian Mountain, Gunnison County, Colo. Sp. gr.: B, 3.448 at 25°; C, 3.452 at 17°. Analysis by L. G. Eakins.

D. From Shasta County, Cal. Analysis by W. T. Schaller.

	A	B	C	D
SiO_2	38.54	38.21	37.22	38.22
Al_2O_3	28.39	28.70	24.09	25.12
Fe_2O_3	6.89	8.16	12.80	8.75
FeO	.50		.79	1.25
MnO			.11	.19
MgO	Trace.		Trace.	Trace.
CaO	24.12	24.30	23.36	22.77
Na_2O		.21	.06	.11
K_2O				.06
H_2O-	2.26	.10	1.61	.52
H_2O+				3.04
TiO_2				.33
F	None.	.35	.06	
	100.70	100.03	100.10	100.36
Less O		.15	.02	
		99.88	100.08	

PIEDMONTITE.

From the rhyolite of Pine Mountain, near Monterey station, Maryland. Contains a little admixed quartz. Analysis by W. F. Hillebrand.

SiO_2	47.37
Al_2O_3	18.55
Ce_2O_3	.75
Other rare earths, mol. wt. at 295	1.28
Fe_2O_3	4.02
Mn_2O_3	6.85
MnO	1.92
PbO	.14
CuO	.11
CaO	15.82
MgO	.25
K_2O	.68
Na_2O	.23
Li_2O	Trace.
H_2O-	.14
H_2O+	1.94
P_2O_5	Trace.
	100.05

ALLANITE.

From Platte Mountain, Douglas County, Colo. Sp. gr., 3.52 at 29°. Analysis by L. G. Eakins. See Proc. Colorado Sci. Soc., vol. 2, p. 32.

SiO_2	31.13
Al_2O_3	11.44
Fe_2O_3	6.24
Ce_2O_3	12.50
$(La, Di)_2O_3$	10.98
FeO	13.59
BaO	.27?
MnO	.61
CaO	9.44
MgO	.16
K_2O	Trace.
Na_2O	.56
H_2O	2.78
CO_2	.21
P_2O_5	Trace.
	99.91

PREHNITE.

A. From Paterson, N. J. Analysis by G. Steiger.

B. From Franklin Furnace, N. J. Collected by C. Palache. Analysis by Steiger. Sp. gr., 2.965.

C. From Smiths Mountain, near Oak Grove, San Diego County, Cal. Sp. gr., 2.895 to 2.909.

D. Crystals from C. Analyses C, D, by W. T. Schaller.

E. From Fassa, Tyrol. Analysis by E. A. Schneider.

	A	B	C	D	E
SiO_2	42.31	43.30	43.48	42.63	43.32
Al_2O_3	19.95	22.70	24.52	26.64	25.50
Fe_2O_3	6.20	.34	.34	....	Trace.
FeO	None.			....	....
CaO	26.63	27.35	27.19	27.06	26.49
MgO	None.	None.	....	....	....
Na_2O	....	.93	....	....	....
K_2O	....	.18	....	....	....
H_2O at 100°	.21	.24	4.32	4.26	.17
H_2O at 250°-300°	4.81	4.85			.14
H_2O by ignition					4.70
F	....	....	.17	....	....
MnO	....	.30	....	....	....
ZnO	....	Trace.	....	....	....
CuO	....	Trace?	....	....	....
	100.11	100.19	100.02	100.58	100.82

TOPAZ.

A. White, opaque topaz from Stoneham, Maine. Sp. gr., 3.51.

B. Alteration product of A, greenish. Sp. gr., 3.42. Analyses A and B by J. E. Whitfield. See discussion by Clarke in Bull. 27.

C. Topaz from Florissant, Colo. Sp. gr., 3.578 at 22°. Analyzed by W. F. Hillebrand, and described in Bull. 20.

	A	B	C
SiO_2	31.92	35.15	33.15
Al_2O_3	57.38	53.18	57.01
CaO	....	1.32	....
MgO	....	.17	....
K_2O	.15	1.52	....
Na_2O	1.33	1.28	....
H_2O	.20	.90	....
F	16.99	12.88	16.04
	107.97	106.40	106.20
O equivalent to F	7.16	5.42	6.75
	100.81	100.98	99.45

The final alteration of the Stoneham topaz is into muscovite. (See p. 330.) The alteration product here given represents the beginning of the process.

SILLIMANITE.

A. Fibrolite adze from Brittany. Sp. gr., 3.147. Analysis by F. W. Clarke. See Bull. 60.

B. From Tuolumne County, Cal. Analysis by H. N. Stokes.

	A	B
SiO_2	34.66	36.70
Al_2O_3	63.24	62.18
Fe_2O_3	Trace.	....
MgO	.37	.27
H_2O, ignition	1.31	....
	99.58	99.15

KYANITE.

Pale-green variety, associated with the dumortierite of Clip, Ariz. Analyzed by W. F. Hillebrand. Titanic oxide is present in appreciable amounts, but was not separated from alumina. The mineral contained a few black, nonmagnetic grains, which may have carried the titanium. Sp. gr., 3.656 at 18.5°.

SiO_2	36.30
$Al_2O_3(TiO_2)$	62.51
Fe_2O_3	.70
FeO	Undet.
CuO	Trace.
Ignition	0.40
	99.91

CUSTERITE.

A new species, collected by J. B. Umpleby, about 3½ miles south of Mackay, Custer County, Idaho. Analysis by W. T. Schaller. Described in Am. Jour. Sci., 4th ser., vol. 36, p. 385.

SiO_2	32.17
CaO	55.11
MgO	1.19
H_2O	5.30
F	8.12
Magnetite	1.00
	102.89
Less O	3.42
	99.47

ILVAITE.

From Golconda mine, South Mountain, Owhyee County, Idaho. Analysis by W. F. Hillebrand. Sp. gr., 4.059 at 31°.

SiO_2	29.16
Al_2O_3	.52
Fe_2O_3	20.40
FeO	29.14
MnO	5.51
CaO	13.02
MgO	.15
Na_2O	.08
H_2O-	.15
H_2O+	2.64
	100.41

CALAMINE.

White, highly crystalline. From Sterling, N. J. Analysis by George Steiger.

SiO_2	24.15
Al_2O_3	.19
Fe_2O_3	
ZnO	67.55
CaO	.12
H_2O-	.27
H_2O+	7.68
	99.96

LAWSONITE.

From Tiburon Peninsula, Cal. Collected by F. L. Ransome. Analysis by W. F. Hillebrand.

SiO_2	38.45
TiO_2	.38
Al_2O_3	31.35
Fe_2O_3	.86
FeO	.10
MnO	Trace.
CaO	17.52
MgO	.17
K_2O	.23
Na_2O	.06
Ignition	11.21
	100.33

STAUROLITE.

Altered staurolite from Liberty Grove, Cecil County, Md. About two-thirds muscovite. Analysis by George Steiger.

SiO_2	50.17
TiO_2	.55
Al_2O_3	27.97
Fe_2O_3	6.13
FeO	1.18
MgO	1.15
K_2O	7.77
Na_2O	.48
H_2O-	.42
H_2O+	3.94
P_2O_5	.06
	99.82

GADOLINITE.

Analyses by L. G. Eakins.

A. From Llano County, Tex. Sp. gr., 4.239 at 17.4°.

B, C. From Devils Head Mountain, Douglas County, Colo. Specific gravities: B, 4.56 at 17°; C, 4.59 at 25.5°. Described in Proc. Colorado Sci. Soc., vol. 2, pt. 1, p. 32.

	A	B	C
SiO_2	23.79	22.13	21.86
ThO_2	.58	.89	.81
Al_2O_3	....	2.34	.54
Fe_2O_3	.96	1.13	3.59
Ce_2O_3	2.62	11.10	6.87
$(La,Di)_2O_3$	5.22	21.23	19.10
Y_2O_3	[a]41.55	[b]9.50	[b]12.63
Er_2O_3		[b]12.74	[b]15.80
FeO	12.42	10.43	11.36
MnO	Trace.	....	.11
GlO	11.33	7.19	5.46
CaO	.74	.34	.47
MgO	Trace.	.14	.16
K_2O	Trace.	.18	.20
Na_2O	Trace.	.28	.32
H_2O	1.03	.86	.74
P_2O_5	.05	....	....
	100.29	100.48	100.02

[a] Molecular weight, 260.

[b] Molecular weight Y, Er group: in B, 296; in C, 294.

YTTRIALITE.

From the Baringer mine, Llano County, Tex. Analyzed by W. F. Hillebrand, and discussed in Am. Jour. Sci., 4th ser., vol. 13, p. 145.

SiO_2	29.63	PbO	0.80
TiO_2	.05	CaO	.67
ThO_2	10.85	MgO	.16
UO_2	1.64	H_2O-	.32
Ce_2O_3	3.07	H_2O+	.04
La_2O_3 group, mol. wt., 335.6	5.18	CO_2	.11
Y_2O_3 group, mol. wt., 265.8	43.45	P_2O_5	.12
Fe_2O_3	.76	A, He, F, and alkalies by difference	.31
FeO	1.90		
MnO	.88		100.00

ROWLANDITE.

From Llano County, Tex. Analysis by W. F. Hillebrand, with discussion in Bull. 113. Sp. gr., 4.513 at 15.5°.

SiO_2	26.04	MgO	1.62
X [a]	.39	Alkalies	.28
ThO_2	.59	H_2O	.24
Ce_2O_3	5.06	CO_2	.34
La_2O_3 group, mol. wt., 336.8	9.34	F	3.87
Yt_2O_3 group, mol. wt., 266.2	47.70	P_2O_5	Trace
Fe_2O_3	.09		101.12
FeO	4.39	O equivalent to F	1.63
MnO	.67		99.49
CaO	.50		

MACKINTOSHITE.

From Llano County, Tex. Analyzed by W. F. Hillebrand and discussed in Bull. 113. Sp. gr., 5.43 at 21.4°. Only nine-tenths of a gram available for analysis.

SiO_2	13.90	CaO	0.59
UO_2	22.40	MgO	.10
ZrO_2	.88	K_2O	.42
ThO_2	45.30	$(Na, Li)_2O$	.68
Ce_2O_3		P_2O_5	.67
La_2O_3 group	1.86	H_2O-	.50
Yt_2O_3 group		H_2O+	4.31
PbO	3.74		
FeO	1.15		96.50

CYRTOLITE.

A doubtful mineral from Devils Head Mountain, Douglas County, Colo. Analyses by W. F. Hillebrand, with description in Proc. Colorado Sci. Soc., vol. 3, pt. 1, p. 44. Brown crystalline growths of irregular form. Sp. gr.: A, 3.70; B, 3.60; C, 3.64. The material may be a mixture of cyrtolite, or some analogous alteration of zircon, with limonite and a phosphate.

---

[a] A mixture of indefinable earths with some uranium and a trace of titanium.

	A	B	C
SiO_2	20.06	20.64	19.21
Ta_2O_5	47.99	.71	51.00
SnO_2		.03	
ZrO_2		47.81	
ThO_2	1.16	1.20	.60
Ce_2O_3	.06		
$(La,Di)_2O_3$	.19		
Er_2O_3	4.77	4.76	4.55
Y_2O_3	2.27	2.48	3.13
Fe_2O_3	5.53	5.97	4.86
MnO	.47	.57	.33
CaO	1.99	1.98	2.15
MgO	.13	.11	....
K_2O	.20	.10	.17
Na_2O	.46	.50	.42
H_2O	12.87	12.00	12.97
P_2O_5	1.64	1.75	.98
F	.25	.42	.42
	100.04	100.98	100.74

DANBURITE.

From Russell, N. Y. Analysis by J. E. Whitfield. See Bull. 55.

SiO_2	49.70
B_2O_3	25.80
CaO	23.26
Fe_2O_3, Al_2O_3	1.02
Ignition	0.20
	99.98

DATOLITE.

From Bergen Hill, N. J. Analysis by J. E. Whitfield. See Bull. 55.

SiO_2	35.74
B_2O_3	22.60
CaO	35.14
FeO	.31
H_2O	6.14
	99.93

AXINITE.

Analyses A, B, by J. E. Whitfield, with discussion in Bull. 55.
A. Clove brown, from Cornwall, England. Translucent.
B. Pearl gray, from Bourg d'Oisans, Dauphiny. Transparent.
C. From Moosa Canyon, Bonsall, San Diego County, Cal.
D. From Consumnes copper mine, Amador County, Cal.
Analyses C, D, by W. T. Schaller.

	A	B	C	D
SiO_2	42.10	41.53	42.61	42.79
Al_2O_3	17.40	17.90	17.43	16.38
Fe_2O_3	3.06	3.90	.38	....
FeO	5.84	4.02	7.53	4.22
CaO	20.53	21.66	19.74	19.21
MnO	4.63	3.79	4.10	8.76
MgO	.66	.74	.44	.09
B_2O_3	4.64	4.62	6.04	[a] 6.70
H_2O	1.80	2.16	1.56	1.85
	100.66	100.32	99.83	100.00

[a] By difference.

DUMORTIERITE.

A. Harlem, N. Y. Analysis by R. B. Riggs. See Am. Jour. Sci., 3d ser., vol. 34, p. 406. Contained some tourmaline.

B. Harlem, N. Y. Analysis by J. E. Whitfield.

C. Near Clip, Yuma County, Ariz. Analysis by J. E. Whitfield.

D. Purified sample from Clip. Analysis by Whitfield. Specific gravity a little over 3.265. See note by Whitfield in Bull. 60 and paper by Diller and Whitfield in Bull. 64.

E, F. Two samples from Dehesa, San Diego County, Cal.

G. North fork of Washougal River, Skamania County, Wash. Analyses E, F, G, by W. T. Schaller, and discussed by him in Bull. 262.

	A	B	C	D	E	F	G
SiO_2	34.82	31.44	31.52	27.99	28.58	28.78	28.51
TiO_2	....	....	....	....	....	....	.95
Ti_2O_3	....	....	....	....	1.49	1.40	....
Al_2O_3	55.30	68.91	63.96	64.49	63.31	63.30	59.75
Fe_2O_3	Trace.	....	....	....	.21	.25	2.48
CaO	Trace.	....	Trace.	....	....	....	.68
MgO	.57	....	.52	Trace.	....	....	....
Na_2O	1.76	....	.37	....	....	....	....
K_2O	1.04	....	.11	....	....	....	....
H_2O	[a] 2.96	....	[a] 1.34	[a] 1.72	1.53	1.51	2.12
B_2O_3	4.07	Trace.	2.62	4.95	5.21	5.53	5.54
P_2O_5	....	....	....	.20	....	....	....
	100.52	100.35	100.14	99.35	100.33	100.77.	100.03

[a] Loss on ignition.

TOURMALINE.

LITHIA TOURMALINE.

Analyses A to H, inclusive, by R. B. Riggs. Discussed by Riggs in Bull. 55.

A. Pink center of crystals having a green margin, from Calhao, province of Minas Geraes, Brazil. Sp. gr., 3.028.

B. Pale green, border of A.

C. Olive green, also from Calhao, Brazil.

D. Rose colored, massive, from Black Mountain, Rumford, Maine. Sp. gr. 2.997.

E. Dark green, massive, same locality as D.

	A	B	C	D	E
SiO_2	37.19	37.39	36.91	38.07	36.53
Al_2O_3	42.43	39.65	38.13	42.24	38.10
Fe_2O_3	None.	.15	.31	....	None.
FeO	.52	2.29	3.19	.26	6.43
MnO	.79	1.47	2.22	.35	.32
MgO	None.	None.	.04	.07	None.
CaO	.57	.49	.38	.56	.34
Li_2O	1.73	1.71	1.61	1.59	.95
Na_2O	2.24	2.42	2.70	2.18	2.86
K_2O	.23	.25	.28	.44	.38
P_2O_5	None.	Trace.	.11	None.	Trace.
B_2O_3	10.06	10.29	9.87	9.99	10.22
H_2O	3.90	3.63	3.64	4.26	3.52
F	Trace?	.32	.14	.28	.16
	99.66	100.06	99.53	100.29	99.81
O equivalent to F	....	.13	.06	.12	.07
	....	99.93	99.47	100.17	99.74

F. Colorless to very pale pinkish or greenish crystals, Auburn, Maine. Sp. gr., 3.07.

G. Light-green crystals, Auburn, Maine.

H. Dark green, massive tourmaline, Auburn, Maine.

I. Pink, Mesa Grande, San Diego County, Cal.

J. Pale green, Mesa Grande.

K. Pale-rose color, Island of Elba. Sp. gr., 3.04–3.05.

Analyses I, J, K, by W. T. Schaller. Schaller's analyses are published and discussed by him in Zeitschr. Kryst. Min., vol. 51, p. 321.

	F	G	H	I	J	K
SiO_2	38.14	37.85	36.26	37.57	36.72	37.89
Al_2O_3	39.60	37.73	36.68	42.18	41.27	43.85
Ti_2O_3	......	......	......	Trace.	.06	.04
Fe_2O_3	.30	.42	.15	.19	1.13	......
FeO	1.38	3.88	7.07			.11
MnO	1.38	.51	.72	.24	1.48	.11
MgO	Trace.	.04	.16	None.	None.	None.
CaO	.43	.49	.17	1.20	.87	.07
Li_2O	1.34	1.34	1.05	1.92	1.76	1.66
Na_2O	2.36	2.16	2.88	2.05	2.23	2.43
K_2O	.27	.62	.44	None.	None.	None.
B_2O_3	10.25	10.55	9.94	10.65	10.60	10.28
P_2O_5	Trace.	Trace.	Trace.	......	......	......
H_2O	4.16	4.18	4.05	3.38	3.33	3.47
F	.62	.62	.71	.39	.31	.10
	100.23	100.39	100.28	99.77	99.76	100.01
Less O	.26	.26	.30	.17	.13	.04
	99.97	100.13	99.98	99.60	99.63	99.97

The following analyses represent alteration products of lithia tourmaline:

L. From the Rumford rubellite.

M. From the rubellite of Hebron, Maine.

N. Pink tourmaline, Pala, San Diego County, Cal., partly altered.

O. Tourmaline N, almost completely altered. Analyses L, M, by Riggs; N, O, by Schaller.

	L	M	N	O
SiO_2	53.03	43.90	36.98	37.05
Al_2O_3	31.67	38.71	43.69	44.25
Fe_2O_3	.51	.58	......	......
FeO	......	.25	......	......
MnO	Trace.	.04	Trace.	Trace.
MgO	Trace.	.05	Trace.	.10
CaO	Trace.	.41	.25	.22
Li_2O	.26	......	1.28	1.27
Na_2O	.54	1.05	2.02	1.06
K_2O	9.44	10.92	2.29	1.95
B_2O_3	Trace.	Trace.	[a] 7.66	[a] 2.46
H_2O-	4.80	4.25	1.16	.83
H_2O+			4.67	10.81
F	Trace?	None.	Undet.	Undet.
	100.25	100.16	100.00	100.00

[a] By difference.

MAGNESIAN AND IRON TOURMALINES.

Analyses A to L by R. B. Riggs. See Bull. 55.

A. White to light-brown crystals, Dekalb, St. Lawrence County, N. Y. Sp. gr., 3.085.

B. Brown tourmaline, Gouverneur, St. Lawrence County, N. Y.

C. Cinnamon-brown crystals, Hamburg, N. J.

D. Brilliant black crystals, Pierrepont, St. Lawrence County, N. Y. Sp. gr., 3.08.
E. Dark-brown crystals, Orford, N. H.
F. Dark-brown crystals, Monroe, Conn.

	A	B	C	D	E	F
SiO_2	36.88	37.39	35.25	35.61	36.66	36.41
TiO_2	.12	1.19	.65	.55	.23	1.61
Al_2O_3	28.87	27.79	28.49	25.29	32.84	31.27
Fe_2O_3	....	.10	None.	.44	None.	None.
FeO	.52	.64	.86	8.19	2.50	3.80
MnO	None.	None.	None.	Trace.	Trace.	Trace.
MgO	14.53	14.09	14.58	11.07	10.35	9.47
CaO	3.70	2.78	5.09	3.31	1.35	.98
SrO	Trace.	Trace.	Trace.	None.	Trace.	Trace.
Li_2O	Trace.	Trace.	Trace.	Trace.	Trace.	None.
Na_2O	1.39	1.72	.94	1.51	2.42	2.68
K_2O	.18	.16	.18	.20	.22	.21
B_2O_3	10.58	10.73	10.45	10.15	10.07	9.65
P_2O_5	Undet.	None.	Trace.	Trace.	None.	Trace.
H_2O	3.56	3.83	3.10	3.34	3.78	3.79
F	.50	Trace?	.78	.27	Trace?	None.
	100.83	100.42	100.37	99.93	100.42	99.87
O equivalent to F	.21	....	.33	.11	....	....
	100.62	....	100.04	99.82	....	....

G. Massive black tourmaline, Auburn, Maine. Sp. gr., 3.19.
H. Massive black tourmaline, Paris, Maine.
I. Black tourmaline, Calhao, Brazil. Sp. gr., 3.20.
J. Black tourmaline, Haddam, Conn.

	G	H	I	J
SiO_2	34.99	35.03	34.63	34.95
TiO_2	None.	....	....	.57
Al_2O_3	33.96	34.44	32.70	31.11
Fe_2O_3	None.	1.13	.31	.50
FeO	14.23	12.10	13.69	11.87
MnO	.06	.08	.12	.09
MgO	1.01	1.81	2.13	4.45
CaO	.15	.24	.33	.81
Li_2O	Trace.	.07	.08	Trace.
Na_2O	2.01	2.03	2.11	2.22
K_2O	.34	.25	.24	.24
B_2O_3	9.63	9.02	9.63	9.92
P_2O_5	Trace.	Trace.	None.	Trace.
H_2O	3.62	3.69	3.49	3.62
F	None.	None.	.06	None.
	100.00	99.89	99.52	100.35
O equivalent to F	....	....	.02	....
	....	....	99.50	....

K. Black crystal, Nantic Gulf, Baffin Land. Sp. gr., 3.095.

L. Black crystal, Stony Point, Alexander County, N. C. Sp. gr., 3.13.

M. Brown tourmaline from near Colfax, Nevada County, Cal. Fine, radiating needles. Sp. gr., 3.065. Incomplete analysis by W. H. Melville. See Bull. 90.

N. Chrome tourmaline from near Etchison, Montgomery County, Md. Analysis by T. M. Chatard. See Bull. 64.

O. Black tourmaline, Lost Valley, San Diego County, Cal.

P. Black tourmaline, Ramona, San Diego County, Cal.

Analyses O, P by W. T. Schaller.

	K	L	M	N	O	P
SiO_2	35.34	35.56	36.40	36.57	35.96	35.21
TiO_2	.40	.55	....	.09	[a] .36	[a] .23
Al_2O_3	30.49	33.38	33.64	32.58	33.28	36.07
Cr_2O_3	....	....	....	4.32	....	....
Fe_2O_3	None.	None.	3.13	.79	11.04	11.11
FeO	8.22	8.49				
MnO	Trace.	.04	....	Trace.	.13	.98
NiO	....	....	....	.05	....	....
MgO	7.76	5.44	10.01	9.47	3.48	.19
CaO	2.32	.53	1.51	.75	.42	.25
SrO	Trace.	None.	....	....	....	....
Li_2O	Trace.	Trace.	....	Trace.	None.	Trace.
Na_2O	1.76	2.16	2.49	2.22	2.16	1.92
K_2O	.15	.24	.12	.13	None.	None.
B_2O_3	10.45	10.40	[b] 8.74	8.90	10.61	10.43
P_2O_5	None.	(?)	....	.04	....	....
H_2O	3.60	3.63	3.53	3.74	3.31	3.51
F	None.	None.	.74	.06	None.	None.
	100.49	100.42	100.31	99.71	100.75	99.90
O equivalent to F	....	....	.31	.02	....	....
	....	....	100.00	99.69	....	....

[a] Ti_2O_3. [b] By difference.

GYROLITE.

A. Associated with the apophyllite of New Almaden, Cal. Fibrous. Analyzed by F. W. Clarke and described in Bull. 64.

B. From Fort Point, San Francisco, Cal. Analyzed by W. T. Schaller and described in Bull. 262.

	A	B
SiO_2	52.54	53.47
Al_2O_3	.71	.22
Fe_2O_3		Trace.
CaO	29.97	32.00
MgO	....	Trace.
Na_2O	.27	1.25
K_2O	1.56	Trace.
H_2O-	14.60	5.93
H_2O+		7.28
F	.65	None.
	100.30	100.15
Less O	.27	
	100.03	

APOPHYLLITE.

From Table Mountain, Golden, Colo. Described by Cross and Hillebrand in Bull. 20. Analyses by W. F. Hillebrand.

A. Apophyllite.

B. Decomposition product of apophyllite.

	A	B
SiO_2	51.89	67.96
Al_2O_3	1.54	8.48
Fe_2O_3	.13	1.04
CaO	24.51	5.47
MgO	....	.53
K_2O	3.81	1.23
Na_2O	.59	[a] .74
H_2O	16.52	14.55
F	1.70	None.
	100.69	100.00
O equivalent to F	.72	
	99.97	

[a] By difference.

PTILOLITE.

Described as a new species by Cross and Eakins in Am. Jour. Sci., 3d ser., vol. 32, p. 117, and vol. 44, p. 96. Analyses by L. G. Eakins.

A. From Green Mountain, Jefferson County, Colo.

B. From 3 miles south of Silver Cliff, Custer County, Colo.

	A	B
SiO_2	70.35	67.83
Al_2O_3	11.90	11.44
CaO	3.87	3.30
K_2O	2.83	.64
Na_2O	.77	2.63
H_2O at 110°	10.18	3.62
H_2O at 125°		1.31
H_2O at 300°		5.41
H_2O at redness		3.10
	99.90	99.28

HEULANDITE.

A. From Green Mountain, Jefferson County, Colo. Analysis by L. G. Eakins.

B. From Anthracite Creek, Gunnison County, Colo. Analysis by L. G. Eakins. Sp. gr. 2.24 at 20.1°.

C. From Berufiörd, Iceland. Analysis by George Steiger.

	A	B	C
SiO_2	59.17	57.38	57.10
Al_2O_3	16.80	17.18	16.82
Fe_2O_3		Trace.	
MgO			.07
CaO	7.10	8.07	6.95
SrO			.46
Na_2O	1.37	.82	1.25
K_2O	.34	.40	.42
H_2O at 110°	15.45	2.57	3.61
H_2O at 125°		1.10	13.00
H_2O at 300°		11.70	
H_2O at redness		.90	
	100.23	100.12	99.68

STILBITE.

A. From Wassons Bluff, near Parrsboro, Nova Scotia. Analysis by George Steiger.

B. From Italian Mountain, Gunnison County, Colo. Analysis by L. G. Eakins.

C. From Table Mountain, Golden, Colo. Described by Cross and Hillebrand in Bull. 20. Analysis by W. F. Hillebrand.

	A	B	C
SiO_2	55.41	57.75	54.67
Al_2O_3	16.85	16.64	16.78
Fe_2O_3	.18		
MgO	.05		
CaO	7.78	8.58	7.98
Na_2O	1.23	Trace.	1.47
H_2O-	3.60	17.17	19.16
H_2O+	15.41		
	100.51	100.14	100.06

LAUMONTITE.

From Table Mountain, Golden, Colo. Described by Cross and Hillebrand in Bull. 20. Analyses by W. F. Hillebrand.

A. Yellow grains.

B. White crystals.

	A	B
SiO_2	51.43	52.07
Al_2O_3	21.52	21.30
Fe_2O_3	.94	......
CaO	11.88	11.24
K_2O	.35	.42
Na_2O	.19	.48
H_2O	13.81	14.58
	100.12	100.09

CHABAZITE.

A. From Wassons Bluff, near Parrsboro, Nova Scotia. Analysis by George Steiger.

B, C. From Table Mountain, Golden, Colo. Described by Cross and Hillebrand in Bull. 20. Analyses by W. F. Hillebrand.

	A	B	C
SiO_2	50.78	47.86	47.18
Al_2O_3	17.18	19.30	19.67
Fe_2O_3	.40	.12	....
MgO	.04	....	....
CaO	7.84	9.94	9.74
SrO	....		.43
Na_2O	1.28	.52	.51
K_2O	.73	.35	.37
H_2O-	5.22	22.07	4.76
H_2O+	16.63		17.39
	100.10	100.16	100.05

LEVYNITE.

From Table Mountain, Golden, Colo. Described by Cross and Hillebrand in Bull. 20. Analyses by W. F. Hillebrand.

A. Crystals of levynite.

B. Associated fibrous variety.

	A	B
SiO_2	46.76	46.97
Al_2O_3	21.91	22.39
CaO	11.12	10.85
K_2O	.21	1.17
Na_2O	1.34	.79
H_2O	18.65	18.03
	99.99	100.20

ANALCITE.

A. From Wassons Bluff, near Parrsboro, Nova Scotia. Analysis by George Steiger. See Bull. 207.

B. From Table Mountain, Golden, Colo. Analysis by George Steiger. See Bull. 207.

C, D. From Table Mountain. Described by Cross and Hillebrand in Bull. 20. Analyses by W. F. Hillebrand.

	A	B	C	D
SiO_2	57.06	55.72	55.82	55.80
Al_2O_3	21.48	23.06	22.42	22.45
Fe_2O_3	.13		....	....
CaO	.16	.17	....	....
Na_2O	12.20	12.46	13.48	13.45
H_2O-	.58	.13	8.38	8.35
H_2O+	8.38	8.26		
	99.99	99.80	100.10	100.05

NATROLITE.

A. From Bergen Hill, N. J. Analysis by George Steiger. See Bull. 207.

B. From Magnet Cove, Ark. Analysis by W. H. Melville. Described in Bull. 90. Sp. gr., 2.261.

C. From South Table Mountain, Golden, Colo. Described by Cross and Hillebrand in Bull. 20. Analysis by W. F. Hillebrand.

	A	B	C
SiO_2	46.62	47.56	43.66
Al_2O_3	26.04	26.82	24.89
Fe_2O_3	None.	.23	....
CaO	1.48	.13	4.87
MgO	None.	.09	....
Na_2O	15.67	15.40	14.66
H_2O-	.39	.07	[a] 8.09
H_2O+	10.18	9.56	....
CO_2	....	....	[b] 3.83
	100.38	99.86	100.00

[a] By difference. Too little material for complete analysis. [b] Calculated to satisfy total lime.

SCOLECITE.

A. From Whale Cove, Grand Manan, New Brunswick. Analysis by George Steiger. See Bull. 207.

B. From Italian Mountain, Gunnison County, Colo. Analysis by L. G. Eakins. Sp. gr., 2.247 at 17.2°.

C. From Table Mountain, Golden, Colo. Described by Cross and Hillebrand in Bull. 20. Analysis by W. F. Hillebrand.

	A	B	C
SiO_2	45.86	45.90	46.03
Al_2O_3	25.78	26.51	25.28
Fe_2O_3	....	....	.27
CaO	13.92	14.17	12.77
MgO	....	Trace.	....
Na_2O	.41	Trace.	1.04
K_2O	....	....	.13
H_2O-	.40	....	[a] 14.48
H_2O+	13.65	13.79	
	100.02	100.37	100.00

[a] By difference.

MESOLITE.

A. From North Table Mountain, Golden, Colo. Described by Cross and Hillebrand in Bull. 20. Analysis by W. F. Hillebrand.

B. From Osterö, Faroe Islands. Analysis by G. Steiger.

	A	B
SiO_2	46.17	45.97
Al_2O_3	26.88	25.98
CaO	8.77	9.69
Na_2O	6.19	4.79
K_2O	......	None.
H_2O-	12.16	1.34
H_2O+		12.04
	100.17	99.81

THOMSONITE.

From Table Mountain, Golden, Colo. Described by Cross and Hillebrand in Bull. 20. Analyses A, B, C, D, E by W. F. Hillebrand. Analysis F by George Steiger; published in Bull. 207. A represents reddish spherules; F, a mass of fibrous structure.

	A	B	C	D	E	F
SiO_2	40.52	40.88	40.68	41.21	42.66	41.13
Al_2O_3	29.22	29.68	30.12	29.71	29.25	29.58
Fe_2O_3	.79	......	......	......	......	......
CaO	12.43	11.88	11.92	11.34	10.90	11.25
Na_2O	4.31	4.72	4.44	5.62	4.92	5.31
H_2O-	12.79	12.91	12.86	12.20	12.28	1.01
H_2O+						12.12
	100.06	100.07	100.02	100.08	100.01	100.40

HYDRONEPHELITE.

From the elæolite syenite of Litchfield, Maine. Described by Clarke as a new species in Bull. 42. Analyses by F. W. Clarke. Sp. gr., 2.263, determined by J. S. Diller.

A, B. Slightly impure. Two distinct samples.

C. Carefully purified material dried at 100°.

	A	B	C
SiO_2	38.90	39.24	38.90
Al_2O_3	33.98	33.16	33.62
Fe_2O_3	Trace.	Trace.	....
CaO	.05	Trace.	.07
Na_2O	13.21	13.07	13.07
K_2O	1.01	.88	1.12
H_2O	13.12	13.30	12.98
	100.27	99.65	99.85

MUSCOVITE.

A. From the Hatch farm, Auburn, Maine. Broad plates, bordered by lepidolite. Analysis by R. B. Riggs.

B. Greenish muscovite, Auburn, Maine. Analysis by E. A. Schneider.

C. Altered muscovite, Mount Mica, Paris, Maine. Occurs as a white enamel on ordinary mica. Analysis by F. W. Clarke.

D. Well-crystallized muscovite from the hiddenite mine, Stony Point, Alexander County, N. C. Analysis by F. W. Clarke.

E. White muscovite from Miask, Ural Mountains, Siberia. Analysis by E. A. Schneider.

F. Mica separated from quartz schist. Shoemaker's quarry, near Stevenson station, Green Spring Valley, Md. Analysis by E. A. Schneider.

G. Mica from the Eureka tunnel, St. Peters Dome, near Pikes Peak, Colo. Analysis by W. F. Hillebrand. See Bull. 20.

H. Pink muscovite, Mesa Grande, San Diego County, Cal. Analysis by W. T. Schaller.

I. Muscovite associated with the dumortierite of Skamania County, Wash. Analysis by Schaller.

	A	B	C	D	E	F	G	H	I
SiO_2	44.39	46.54	46.61	45.40	44.17	44.93	52.59	45.63	50.13
TiO_2	....	None.	....	1.10	....	1.05	....	Trace.	....
Al_2O_3	35.70	34.96	35.61	33.66	37.35	29.81	29.72	37.42	32.37
Fe_2O_3	1.09	1.59		2.36	1.29	6.10	1.40	Trace.	1.52
FeO	1.07	....	....	....	.20			....	
MnO	Trace.	....	Trace.	....	.10	Trace.	....	.06	....
MgO	....	.32	....	1.86	....	1.16	2.12	None.	.09
CaO	.10	....	Trace.	....	....	....	.26	None.	.15
Li_2O	....	....	....	Trace.	....	Trace.	....	.20	....
Na_2O	2.41	.41	1.76	1.41	1.14	.50	.50	1.43	....
K_2O	9.77	10.38	8.86	8.33	10.00	10.28	8.33	9.95	9.60
H_2O-	5.88	.71	6.50	5.46	1.06	1.38	4.39	....	7.74
H_2O+		4.72			4.67	4.88		4.43	5.08
F	.72	None.	....	.69	.90	.22	....	.77	....
	101.13	99.63	99.34	100.27	100.88	100.31	99.31	99.89	100.68
O equivalent to F	.30	....	....	.29	.37	.09	....	.32	....
	100.83	....	....	99.98	100.51	100.22	....	99.57	....

J. Fuchsite. Etchison post-office, Montgomery County, Md. Analysis by T. M. Chatard. See Bull. 64.

K. Grayish-green, compact mica from Stoneham, Maine. Structure subfibrous. Analysis by T. M. Chatard.

L. Same locality as K. Specimen broadly foliated, micaceous. Analysis by T. M. Chatard. For analyses K and L see Bull. 9.

M. Stoneham, Maine. From alteration of topaz, the outer portion of an altered crystal. Sp. gr., 2.82. Analysis by J. E. Whitfield. Discussed by Clarke in Bull. 27.

N. Pseudomorph from the Rochelle mine, on Running Water River, Wyo. Near liebenerite. Sp. gr., 2.831 at 12.5°. Analyzed by W. F. Hillebrand and described in Bull. 20.

O. Mariposite. From vein of the Josephine gold quartz mine, Bear Valley, Mariposa County, Cal. Color, green. Sp. gr., 2.817 at 29.5°.

P. White mariposite, same locality as O. Sp. gr., 2.787 at 28.5°. Analyses O and P by W. F. Hillebrand, and described in Bull. 167.

Q. Muscovite, Deer Trail mine, Marysvale, Utah. Analysis by W. T. Schaller.

	·J	K	L	M	N	O	P	Q
SiO_2	42.21	45.19	45.34	44.52	45.54	55.35	56.79	46.60
TiO_2	....	....	....	....	....	.18	25.29	....
Al_2O_3	34.55	33.32	33.96	46.19	37.15	25.62		38.56
Cr_2O_3	2.03	....	....	....	.79	.18	None.	....
Fe_2O_3	1.03	....	....	....	....	.63	1.59	....
FeO		4.25	3.96	....	....	.92		....
MnO	Trace.	.58	.51	.21	....	....	....	....
CaO	.47	Trace.	.22	.30	....	.07	.07	....
MgO	3.13	.36	.10	.14	.38	3.25	3.29	.86
Li_2O	....	....	....	....	....	Trace.	Trace.	....
Na_2O	.82	1.57	1.49	2.82	.90	.12	.17	.33
K_2O	9.16	11.06	10.73	2.30	10.70	9.29	8.92	8.40
H_2O-	.20	4.48	4.78	3.74	4.80	4.52	4.72	5.02
H_2O+	6.57							
F	....	....	....	.40	....	....	....	....
	100.17	100.81	101.09	100.62	100.26	100.13	100.84	99.77
O equivalent to F	....	....	....	.16	....	....	....	....
	....	....	....	100.46	....	....	....	....

LEPIDOLITE.

Micas A to G from various localities in Maine. Analyses by R. B. Riggs. Discussion by F. W. Clarke in Bull. 42.

A. From Black Mountain, Rumford. Lilac-purple, granular.
B. From Mount Mica, Paris. Broadly foliated.
C. From Hebron. Purple, coarsely granular.
D. From Auburn. Purple border on plates of muscovite.
E. From Auburn. Purple, coarsely granular.
F. From Norway. White, coarsely granular.
G. From Norway. Brownish, finely granular.

	A	B	C	D	E	F	G
SiO_2	51.52	50.92	48.80	49.62	51.11	49.52	50.17
Al_2O_3	25.96	24.99	28.30	27.30	25.26	28.80	25.40
Fe_2O_3	.31	.30	.29	.31	.20	.40	.87
FeO	Undet.	.23	.09	.07	.07	.24	.45
MnO	.20	Trace.	.08	.55	.17	.07	.23
CaO	.16	Trace.	.10	....	.12	.13	Undet.
MgO	.02	Trace.	.07	....	.01	.02	Undet.
Li_2O	4.90	4.20	4.49	4.34	4.98	3.87	4.03
Na_2O	1.06	2.11	.74	2.17	1.43	.13	13.40
K_2O	11.01	11.38	12.21	8.03	10.51	8.82	
Rb_2O	....	Trace.		2.44	1.29	3.73	
Cs_2O	....	Trace.		.72	.45	.08	
H_2O	.95	1.96	1.73	1.52	.94	1.72	2.02
F	5.80	6.29	4.96	5.45	6.57	5.18	5.06
	101.89	102.38	101.86	102.52	103.11	102.71	101.62
O equivalent to F	2.44	2.64	2.02	2.29	2.76	2.18	2.13
	99.45	99.74	99.84	100.23	100.35	100.53	99.49

Analyses H to M, of lepidolites from San Diego County, Cal., by W. T. Schaller.

H. Red purple lepidolite, Pala. Tourmaline Queen mine.
I. Blue purple, same locality as H.
J. Purple lepidolite, Pala.
K. White lepidolite, Pala.
L. Lepidolite border on muscovite, Mesa Grande.
M. Crystals of lepidolite, Little Three mine, Ramona.
N. Lithia mica, Cassiterite Creek, Cape York, Alaska. Intermediate between lepidolite and zinnwaldite. Analysis by Schaller.

	H	I	J	K	L	M	N
SiO_2	51.12	50.95	50.34	51.25	50.85	51.46	46.80
Al_2O_3	22.70	23.97	28.71	25.62	26.78	23.46	24.50
Fe_2O_3	.80	.82	.11	.12	.60	....	.50
FeO	....	....	Trace?	None.	....	....	6.35
Mn_2O_3	1.34	1.29	....	....	....	....	....
MnO	....	....	.50	.05	.07	....	1.38
MgO	....	....	None.	None.	Trace.	....	....
CaO	....	....	Trace.	Trace.	.10	....	.24
Li_2O	5.12	4.63	2.39	4.31	4.27	6.06	3.73
Na_2O	2.25	2.39	1.59	1.94	1.41	2.09	1.73
K_2O	10.60	10.69	10.37	10.65	10.30	10.71	9.20
H_2O-	2.05	1.91	....	....	....	1.83	.88
H_2O+			3.15	1.60	1.74		
F	6.38	6.11	5.02	7.06	6.71	8.27	8.63
P_2O_5	.04	.04	....	....	....	....	....
	102.43	102.80	102.18	102.60	102.83	103.88	103.94
Less O	2.69	2.57	2.11	2.97	2.82	3.48	3.63
	99.74	100.23	100.07	99.63	100.01	100.40	100.31

COOKEITE.

om Pala, San Diego County, Cal. Analysis by W. T. Schaller.

SiO_2	35.53
Al_2O_3	44.23
MnO	Trace.
MgO	Trace.
CaO	Trace.
Li_2O	2.73
Na_2O	2.11
K_2O	.31
H_2O-	.61
H_2O+	13.57
F	1.46
	100.55
Less O	.61
	99.94

CRYOPHYLLITE.

From Rockport, Mass. Analyses by R. B. Riggs. Discussed by Clarke in Bull. 42.

A. Brilliant, broadly foliated, blackish-green variety.

B. Paler, dull green, less lustrous, probably somewhat altered.

C. Granular, resembling chlorite.

	A	B	C
SiO_2	51.96	51.46	52.17
Al_2O_3	16.89	16.22	16.39
Fe_2O_3	2.63	2.21	4.11
FeO	6.35	7.66	6.08
MnO	.24	.06	.32
CaO	.12	Trace.	Trace.
MgO	.03	.17	Trace.
Li_2O	4.93	4.83	5.03
Na_2O	.92	.95	.60
K_2O	10.66	10.65	10.54
H_2O	1.22	1.06	1.43
F	6.78	7.44	7.02
	102.73	102.71	103.69
O equivalent to F	2.86	3.11	2.95
	99.87	99.60	100.74

BIOTITE.

A. From Merrow Ledge, Auburn, Me. Black. Analysis by F. W. Clarke and R. B. Riggs.

B. Bronze mica, Laurel Creek corundum mine, Rabun County, Ga. Analysis by E. A. Schneider. The loss is due to undetermined volatile matter.

C. Brown mica from the granite of the Yosemite Valley, Cal. Analysis by William Valentine. Described by Turner, Am. Jour. Sci., 4th ser., vol. 7, p. 294.

D. Mica from quartz monzonite, Tioga road, southeast of Mount Hoffman, Mariposa County, Cal. Sp. gr., 3.05 at 21°. Analysis by W. F. Hillebrand. Described by Turner, loc. cit.

E. Black mica from quartz monzonite. About 1 kilometer south of Bloods station, Alpine County, Cal. Analysis by William Valentine. Described by Turner, loc. cit.

F. Reddish-brown mica from pyroxenic gneiss. North Fork of Mokelumne River, above mouth of Bear River, Amador County, Cal. Analysis by William Valentine. Described by Turner, loc. cit.

G. Biotite from the granite of Butte, Mont. See Weed, Jour. Geology, vol. 7, p. 737. Analysis by H. N. Stokes.

H. Biotite from orthoclase gabbro, between Blue and Mud lakes, Livingston ngle, Montana. See W. H. Emmons, Jour. Geol., vol. 16, p. 193. Analysis

	A	B	C	D	E	F	G	H
SiO_2	34.67	36.12	35.64	35.75	35.62	36.62	35.79	33.07
TiO_2		1.18	1.12	3.16	2.61	3.03	3.51	
Al_2O_3	30.09	20.49	18.62	14.70	15.24	14.37	13.70	13.00
V_2O_3				.05				
Cr_2O_3				Trace.				
Fe_2O_3	2.42	3.29	5.54	4.65	4.69	4.04	5.22	17.22
FeO	16.14	5.17	14.60	14.08	13.67	17.09	13.72	
MnO	.85	.17	.79	.45	.74	.40	.19	
NiO		.34		.02				
CoO								
CaO	None.	.28	.90	.17	.95	1.48	.05	2.45
SrO				(?)	Trace.	Trace.		
BaO		.09	Trace.	.12	.26	.33	.13	
MgO	1.98	19.61	9.72	12.37	12.70	9.68	12.13	11.33
Li_2O		Trace.	Trace.		Trace.	Trace.	Trace.	
Na_2O	1.67	.78	.38	.32	.50	.45	.15	.28
K_2O	7.55	8.14	9.22	9.19	7.72	8.20	9.09	6.11
H_2O-	4.64	1.58	.48	1.03	.94	.90	1.21	5.41
H_2O+		.82	2.54	3.64	4.36	3.26	3.64	11.61
P_2O_5			.20	.03	None.	None.	.10	
F	.28	.60	.26	.17	None.	.10	.76	
Cl							.20	
	100.29	98.66	100.01	99.90	100.00	99.95	99.59	100.48
Less O	.12	.26	.11	.07		.04	.37	
	100.17	98.40	99.90	99.83		99.91	99.22	

PHLOGOPITE.

A. From Edwards, St. Lawrence County, N. Y. Outwardly resembles talc. Analysis by E. A. Schneider. Discussed by Clarke and Schneider in Bull. 78.

B. From Burgess, Canada. Brown. Analysis by E. A. Schneider. See Clarke and Schneider, Bull. 78.

C. Phlogopite separated from the wyomingite of the Leucite Hills, Wyo. Described by Cross in Am. Jour. Sci., 4th ser., vol. 4, p. 115. Analysis by W. F. Hillebrand.

The following micas of doubtful character occur in serpentine. Analyses by Charles Catlett. See Bull. 64.

D. Brown mica from the serpentine of Montville, N. J.

E. Yellowish mica, same locality as D.

F. White mica, same locality.

G. White mica from near Easton, Pa.

E, F, and G are perhaps to be called vermiculites rather than micas.

	A	B	C	D	E	F	G
SiO_2	45.05	39.66	42.56	39.38	32.52	39.14	41.82
TiO_2		.56	2.09				
Al_2O_3	11.25	17.00	12.18	15.92	18.14	15.70	11.12
Cr_2O_3			.73				
Fe_2O_3		.27	2.73	.71	2.30	1.68	2.68
FeO	.14	.20	.90	.80			
CaO		None.	.20	.28	1.44	5.24	
SrO			Trace.				
BaO		.62	1.00				
MgO	29.38	26.49	22.40	26.85	29.26	25.44	29.82
Li_2O	.07		Trace.				
Na_2O	.45	.60	.44	.62	1.38	.64	.36
K_2O	8.52	9.97	10.70	9.84	2.78	2.06	6.08
H_2O-	5.37	.66		.38	.76	1.10	.94
H_2O+		2.33	2.35	4.69	10.12	9.10	7.10
CO_2				.30	1.80		
P_2O_5		Trace.	.06				
F		2.24	2.46	.62			
	100.23	100.60	100.80	100.39	100.50	100.10	99.92
O equivalent to F		.94	1.03	.26			
		99.66	99.77	100.13			

LEPIDOMELANE.

A. From Litchfield, Maine. Analyzed by F. W. Clarke and described in Bull. 42.

B. Same as A. Later analysis by Clarke. See Bull. 55.

C. Annite. From Rockport, Mass. Analysis by R. B. Riggs. Discussion by Clarke in Bull. 42.

D. From Port Henry, N. Y. Analysis by E. A. Schneider. See paper by Clarke and Schneider in Bull. 78.

E. From Baltimore, Md. Analysis by F. W. Clarke, and discussed in Bull. 55.

F. From near Pikes Peak, Colo. Siderophyllite? The slightly altered margin of a large crystal.

G. Much-altered central portion of specimen F.

Analyses F and G by F. W. Clarke and R. B. Riggs. Described by Clarke in Bull. 55. Classed by Dana under biotite.

	A	B	C	D	E	F	G
SiO_2	32.09	32.35	32.03	34.52	35.78	34.21	34.63
TiO_2	....	Trace.	3.42	2.70	....	....	....
Al_2O_3	18.52	17.47	11.92	13.22	16.39	16.53	17.95
Fe_2O_3	19.49	24.22	8.00	7.80	14.55	20.15	31.25
FeO	14.10	13.11	30.41	22.27	11.02	14.17	3.01
MnO	1.42	1.02	.21	.41	1.08	.91	.34
CaO	....	None.	.23	None.	None.	.48	.81
MgO	1.01	.89	.06	5.82	8.67	1.34	1.08
NiO, CoO	....	....	....	.30	....	....	....
Li_2O	....	....	Trace.	.04	....	....	....
Na_2O	1.55	.70	1.54	.16	.56	1.43	.89
K_2O	8.12	6.40	8.46	8.59	7.76	6.50	1.96
H_2O-	4.62	4.67	4.19	.57	4.48	4.54	7.82
H_2O+				3.82			
P_2O_5	....	....	....	Trace.	....	....	....
F	None.	None.	Trace.	.34	None.	.08	.54
	100.92	100.83	100.47	100.56	100.29	100.34	100.28
O equivalent to F	....	....	....	.14	....	.03	.22
	....	....	....	100.42	....	100.31	100.06

ROSCOELITE.

Analyses by W. F. Hillebrand.

A. From the Stockslager mine, near Lotus, Eldorado County, Cal. Described by Hillebrand in Bull. 167.

B. Soluble portion of a vanadiferous sandstone from Placerville, Colo. Described by Hillebrand in Am. Jour. Sci., 4th ser., vol. 10, p. 130.

	A	B
SiO_2	45.17	46.06
TiO_2	.78	....
Al_2O_3	11.54	22.55
V_2O_3	24.01	12.84
Fe_2O_3	....	.73
FeO	1.60	....
CaO	....	.44
BaO	....	1.35
MgO	1.64	.92
Li_2O	Trace.	....
Na_2O	Trace.	.22
K_2O	10.37	8.84
H_2O-	.40	1.98
H_2O+	4.29	4.07
	99.80	100.00

MARGARITE.

A. Brownish yellow, from Iredell County, N. C. Analysis by T. M. Chatard. See Bull. 9.

B. Bright green, associated with pink corundum. From Gainesville, Ga. Sp. gr., 3.00. Analysis by T. M. Chatard. See Bull. 9.

C. Inclusion in diorite, Crugers station, near Peekskill, N. Y. Analysis by T. M. Chatard.

	A	B	C
SiO_2	31.15	31.72	32.73
Al_2O_3	49.51	50.03	46.58
FeO	Trace.	Trace.	5.12
MgO	.45	.12	1.00
CaO	11.13	11.57	11.04
Na_2O	2.74	2.26	....
H_2O-	5.68	4.88	.12
H_2O+			4.49
	100.66	100.58	101.08

CHLORITOID.

From a phyllite rock near Liberty, Md. Analysis by L. G. Eakins. See Bull. 168, p. 50.

SiO_2	23.40
Al_2O_3	39.31
Fe_2O_3	5.14
FeO	21.94
MgO	2.18
CaO	Trace.
Na_2O	.20
K_2O	.20
H_2O	6.81
TiO_2	1.19
MnO	Trace.
P_2O_5	Trace.
	100.37

XANTHOPHYLLITE.

Variety waluewite, from the Nikolai-Maximilian mine, district of Slatoust, Urals, iberia. Analysis by E. A. Schneider. Discussion by Clarke and Schneider in Bull. 113.

SiO_2	16.85
TiO_2	Trace.
Al_2O_3	42.33
Fe_2O_3	2.36
FeO	.20
CaO	13.30
MgO	20.77
H_2O-	.04
H_2O+	4.56
	100.40

THE VERMICULITES.

A. Jefferisite from Westchester, Pa. Analysis by E. A. Schneider. Discussed by Clarke and Schneider in Bull. 78.

B. Vermiculite, near jefferisite or culsageeite, from Corundum Hill, N. C. Analyzed by T. M. Chatard and described by him in Bull. 42.

C. Altered biotite from the zircon mine, Green River, Henderson County, N. C. Analysis by E. A. Schneider. Discussed by Clarke and Schneider in Bull. 90.

D. Kerrite, from near Franklin, Macon County, N. C. Analysis by E. A. Schneider. Discussed by Clarke and Schneider in Bull. 78.

E. Lucasite. Described as a new species by T. M. Chatard in Bull. 42. Analysis by Chatard. From Corundum Hill, N. C. Sp. gr., 2.613 at 25.5°.

	A	B	C	D	E
SiO_2	34.20	37.96	38.18	38.13	39.81
TiO_2			1.68		
Al_2O_3	16.58	22.53	14.02	11.22	12.99
Cr_2O_3					.54
Fe_2O_3	7.41	11.12	13.02	2.28	5.29
FeO	1.13	.30	2.22	.18	.11
MnO		.12	.38		.05
NiO				.48	
CoO				Trace.	
CaO		None.	.17		.14
BaO			.06		
MgO	20.41	15.46	14.62	27.39	24.83
Na_2O		Undet.	.48		.20
K_2O		Undet.	5.40		5.76
H_2O-	21.14	12.63	3.20	20.47	3.78
H_2O+			7.32		6.98
	100.87	100.12	100.75	100.15	100.48

F. Hallite from Nottingham, Chester County, Pa.

G. White lennilite from Lenni, Delaware County, Pa.

H. Brown lennilite, same locality.

I. Green lennilite, same locality.

Analyses F to I by E. A. Schneider. Discussion by Clarke and Schneider in Bull 90.

	F	G	H	I
SiO_2	35.54	36.72	35.09	34.90
TiO_2	Undet.	.18	.58	.10
Al_2O_3	9.74	10.06	12.05	10.60
Fe_2O_3	9.07	5.37	6.67	8.57
Cr_2O_3		.26	.46	.23
FeO	.28	.12	.11	.22
MnO	.25	.31	.27	.17
NiO	.16	.20	.20	.19
MgO	30.05	29.40	27.62	28.21
BaO			Trace.	
H_2O-	2.64	6.40	5.70	4.99
H_2O+	12.14	11.37	11.20	11.48
	99.87	100.39	99.95	99.66

J. A vermiculite from Newlin, Chester County, Pa.

K. Painterite from Middletown, Delaware County, Pa.

L. Another sample of painterite.

Analyses J, K, and L by E. A. Schneider. Discussion by Clarke and Schneider in Bull. 90.

M. Hydromica from Rocky Hill, N. J. Analysis by George Steiger. Described by Clarke and Darton in Bull. 167.

N. Analysis M corrected by deduction of calcite, union of like radicles, and recalculation to 100 per cent.

O. Protovermiculite from Magnet Cove, Ark. Analysis by E. A. Schneider. Discussed by Clarke and Schneider in Bull. 90.

	J	K	L	M	N	O
SiO_2	31.23	34.86	33.95	32.72	40.24	34.03
TiO_2	......	Trace.	Trace.	.24	......	Undet.
Al_2O_3	17.52	11.64	12.52	8.41	10.34	14.49
Cr_2O_3	.14	......	......	......	......	......
Fe_2O_3	4.70	3.78	4.40	19.99	24.57	7.71
FeO	1.20	.20	.20	4.24	5.21	.14
MnO	.20	......	......	......	......	.09
NiO	.33	.14	.23	......	......	......
CaO	......	.07	None.	10.30	......	1.88
MgO	31.36	31.32	30.56	5.51	6.78	20.89
Na_2O	......	......	......	.63	......	......
K_2O	......	......	......	.85	2.20	......
H_2O-	1.08	1.64	1.56	2.47	3.03	11.23
H_2O+	12.55	16.78	17.05	6.22	7.03	9.96
CO_2	......	......	......	8.21	......	......
	100.31	100.43	100.47	99.79	100.00	100.42

P. Chloritic vermiculite from Corundum Hill, N. C.

Q. Altered chlorite from Corundum Hill.

Analyses P, Q by T. M. Chatard. Description in Bull. 42.

	P	Q
SiO_2	35.88	32.97
Al_2O_3	20.90	17.88
Fe_2O_3	6.55	4.76
FeO	3.68	.57
MnO	......	Trace.
CaO	.14	None.
MgO	19.90	22.36
Alkalies	Traces.	Undet.
H_2O-	12.71	11.42
H_2O+		10.05
	99.76	100.01

CLINOCHLORE.

A. From West Chester, Pa. Broadly foliated. Analysis by E. A. Schneider. Discussed by Clarke and Schneider in Bull. 78.

B. From the Nikolai-Maximilian mine, district of Slatoust, Urals, Siberia. Analysis by E. A. Schneider. Discussed by Clarke and Schneider in Bull. 113.

C. Leuchtenbergite from Slatoust. Analyst and reference as under B.

D. Kotschubeite from Green Valley, American River Canyon, Cal. Sp. gr., 2.69. Analysis by W. H. Melville. Described by Melville and Lindgren in Bull. 61.

	A	B	C	D
SiO_2	29.87	30.84	30.00	31.74
Al_2O_3	14.48	18.31	20.43	6.74
Cr_2O_3	1.56	......	......	11.39
Fe_2O_3	5.52	1.94	1.68	......
FeO	1.93	1.08	.14	1.23
NiO	.17	......	......	.49
CaO	......	......	.21	.18
MgO	33.06	34.38	34.26	35.18
H_2O-	13.60	.55	.55	.37
H_2O+		13.33	13.20	12.68
	100.19	100.43	100.47	100.00

PROCHLORITE.

From the Aqueduct Tunnel, Washington, D. C. Analysis by E. A. Schneid Described by Clarke and Schneider in Bull. 78.

SiO_2	25.40
Al_2O_3	22.80
Fe_2O_3	2.86
FeO	17.77
MnO	.25
MgO	19.09
H_2O-	.80
H_2O+	11.41
F	Trace.
	100.38

THURINGITE.

A chlorite, probably thuringite, from a vein in the Last Chance mine, Creede. Co Analysis by J. G. Fairchild.

SiO_2	24.34
Al_2O_3	16.46
Fe_2O_3	12.04
FeO	28.89
MgO	5.41
Na_2O	.37
K_2O	Trace.
H_2O-	.35
H_2O+	9.19
TiO_2	Trace?
P_2O_5	Trace.
S	Trace.
MnO	2.75
	99.80

SERPENTINE.[1]

A. From Newburyport, Mass. Analysis by F. W. Clarke.

B. Same locality as A. Analysis by E. A. Schneider. Discussion by Clarke a Schneider in Bull. 78.

C. From Moriah, N. Y. Analysis by Charles Catlett. Described by Merrill, Pro U. S. Nat. Mus., vol. 12, p. 596.

D. From the aqueduct shaft, New York City. Analysis by Charles Catlett. S Merrill, loc. cit., p. 598.

E. From Montville, N. J., light yellowish green.

F. From Montville, darker green. Analyses E, F by Charles Catlett. See Merril Proc. U. S. Nat. Mus., vol. 11, p. 105.

G. From Montville, massive.

H. From Montville, chrysotile. Analyses G, H by E. A. Schneider. Discussic by Clarke and Schneider in Bull. 78.

	A	B	C	D	E	F	G	H
SiO_2	41.32	41.47	39.96	39.92	42.38	40.23	42.05	42.
Al_2O_3			1.07	.08	.07	2.18	.30	.
Fe_2O_3		1.73	3.53	.50	.97	4.02		.
FeO	2.36	.09	3.85	None.	.17	Trace?	.10	Und
MnO			Trace.					Nor
NiO			None.					.
CaO		None.	None.	.90		Trace.	.05	Trac
MgO	41.49	41.70	37.61	42.52	42.14	39.46	42.57	41.
H_2O-	14.54	1.20	13.65	1.36	14.12	14.24	.96	2.
H_2O+		13.86		13.26			13.70	13.
[illegible]				1.64				
	99.71	100.05	99.77	100.18	99.85	100.13	99.73	100.

---

[1] Other analyses of serpentine are given in the section on igneous and crystalline rocks.

I. From Easton, Pa. Resembles a vermiculite. Analysis by E. A. Schneider. See Clarke and Schneider, Bull. 90.

J. Grayish-green serpentine from Corundum Hill, N. C.

K. Picrolite from Buck Creek, Clay County, N. C. Analyses R and S by E. A. Schneider. See Clarke and Schneider. Bull. 78.

L. From the river Poldnewaja, district of Syssert, Urals, Siberia. Analysis by E. A. Schneider. See Clarke and Schneider, Bull. 113.

M. From Greenville, Plumas County, Cal. Analysis by W. H. Melville. Described by Diller in Bull. 150.

N. Chrysotile, from below Grand View, Grand Canyon of the Colorado, Ariz. Analysis by R. C. Wells. Received from J. S. Diller.

	I	J	K	L	M	N
SiO_2	43.71	41.90	42.94	42.55	39.14	43.68
Al_2O_3	3.59	.71	5.05	1.25	2.08	.34
Fe_2O_3	.90	.91		1.56	4.27	.51
FeO	....	Undet.	1.88	1.52	2.04	....
NiO	....	.10	.61	....	....	....
MnO	....	....	....	....	....	.17
CaO	....	....	....	None.	Trace.	.09
MgO	38.58	40.16	36.53	40.05	39.84	40.64
Na_2O	.13	....	....	....	....	.14
K_2O	2.22	....	....	....	....	.11
H_2O-	.46	2.26	1.53	.21	12.70	1.18
H_2O+	10.79	13.90	11.68	12.26		13.12
Chromite	....	....	....	.37	.11	....
	100.38	99.94	100.22	99.77	100.18	99.98

GENTHITE.

From Riddles, Douglas County, Oreg. Analyzed by F. W. Clarke and described by Diller and Clarke in Bull. 60.

SiO_2	44.73
Al_2O_3	1.18
Fe_2O_3	
MgO	10.56
NiO	27.57
H_2O-	8.87
H_2O+	6.99
	99.90

TALC.

A. Apple green, beautifully foliated. From Huntersville, Fairfax County, Va. Analysis by E. A. Schneider.

B. From Deep River, N. C. Analysis by H. C. McNeil.

	A	B
SiO_2	62.27	62.63
Al_2O_3	.15	.55
Fe_2O_3	.95	1.07
FeO	.85	....
MgO	30.95	31.36
MnO	Trace.	....
H_2O-	.07	....
H_2O, ignition	4.84	4.84
	100.08	100.45

MEERSCHAUM.

Magnesian silicates of uncertain character.

A. From Eskihi-Sher, Asia Minor. Analysis by G. Steiger.

B. From Arroyo de San Jose de Gracia, Lower California. Received from W. F. Ferrier. Analysis by W. T. Schaller. Is near saponite.

C. From Alunogen district, Grant County, N. Mex. Received from A. R. Ledoux. Analysis by Schaller.

D. From the Dorsey mine, 12 miles northwest of Silver City, N. Mex. May be sepiolite. Analysis by Steiger.

	A	B	C	D
SiO_2	49.34	52.02	60.97	57.10
Al_2O_3	.29	1.27	9.71	.58
Fe_2O_3				Trace.
CaO	3.10	1.40	.22	.17
MgO	21.70	20.57	10.00	27.16
Na_2O	....	1.31	....	....
K_2O	....	.10	....	....
H_2O-	10.00	[a]23.36	[a]19.14	14.78
H_2O+	9.15			
CO_2	6.95	Trace.	None.	.32
SO_3	Trace.	....	....	....
	100.53	100.03	100.04	100.11

[a] Loss on ignition.

GLAUCONITE.

From Big Goose Canyon, 15 miles southwest of Sheridan, Bighorn Mountains, Wyo. Analysis by George Steiger. Sp. gr., 2.73.

SiO_2	49.23
Al_2O_3	7.11
Fe_2O_3	20.89
FeO	3.06
MnO	Trace.
CaO	Trace.
MgO	3.44
Na_2O	.11
K_2O	8.51
H_2O-	1.83
H_2O+	4.88
	99.06

KAOLINITE.

A. From Hockessen, Del. Analysis by George Steiger.

B. From Aiken, S. C. Analysis by F. W. Clarke.

C. From Aiken. Analysis by Steiger.

D. From Talladega, Ala. Analysis by Charles Catlett.

E. From the Eureka vein, St. Peters Dome, near Pikes Peak, Colo. Analysis by W. F. Hillebrand. Described by Cross and Hillebrand in Bull. 20.

F. From New Discovery mine, Leadville, Colo. Analysis by W. F. Hillebrand.

G. From National Belle mine, Ouray County, Colo. Analysis by W. F. Hillebrand. Sp. gr., 2.611 at 18.5°. Described in Bull. 20.

H. From the Forsyth project, Mont. Analysis by R. C. Wells.

	A	B	C	D	E	F	G	H
SiO_2	48.73	45.56	44.94	43.21	46.06	43.66	46.35	46.47
Al_2O_3	37.02	40.25	39.18	37.27	39.63	37.78	39.59	37.08
Fe_2O_3	.79	....	.52	....	....	....	.11	
CaO	.16	....	....	.11	....	.22	....	.13
MgO	.11	....	....	.10	....	.30	....	.44
Na_2O	.04	....	....	.40	....	Trace.	....	....
K_2O	.41	....	....	.28	....	Trace.	....	....
H_2O-	.52	14.10	.47	5.02	13.77	17.95	13.93	15.67
H_2O+	12.83		13.85	13.48				
P_2O_5	.03	....	.12	....	....	....	....	....
TiO_2	.17	....	.65	....	....	....	....	....
SO_3	....	....	....	....	....	Trace.	....	....
F	....	....	....	....	....	....	.15	....
CaF_2	....	....	....	....	.68	....	....	....
	100.81	99.91	99.73	99.87	100.14	99.91	100.13	99.74
O equivalent to F	....	....	....	....	....	....	.06	....
	....	....	....	....	....	....	100.07	....

HALLOYSITE.

A. From Horse Cave, Ky. Analysis by H. C. McNeil.

B. From Edwards County, Tex. Analysis by McNeil.

C. From the Logan mine, Rico, Colo. Analysis by W. F. Hillebrand.

D. From the Lucia mining district, Elko County, Nev. Pale greenish. Analysis by G. Steiger.

E. From the Detroit copper mine, near Mono Lake, Cal. Analyzed by F. W. Clarke and described in Bull. 9.

F. From Pala, San Diego County, Cal. Pink. Analysis by W. T. Schaller.

	A	B	C	D	E	F
SiO_2	41.69	42.03	38.65	42.11	42.91	43.62
Al_2O_3	35.88	39.25	33.27	33.83	38.13	35.55
Fe_2O_3	.37	.41	.22	.04	....	.21
FeO	....	....	....	.28	....	....
MnO	....	....	....	....	....	.26
CuO	....	....	....	2.83	....	....
CaO	.06	.29	....	.33	....	1.02
MgO	....	....	....	.30	....	.19
Li_2O	....	....	....	....	....	.23
Na_2O	....	....	....	....	....	.19
K_2O	....	....	....	....	....	.03
H_2O-	7.97	2.69	13.70	6.54	18.95	6.63
H_2O+	14.01	15.52	14.34	14.37		12.25
	99.98	100.19	100.18	100.63	99.99	100.18

CIMOLITE.

Rose-red, earthy variety, from Norway, Maine. Analysis by R. B. Riggs. Described by Clarke in Bull. 42.

SiO_2	66.86
Al_2O_3	22.23
Fe_2O_3	.47
FeO	.18
MnO	.07
CaO	.42
MgO	.33
Li_2O	.29
Na_2O	.46
K_2O	.18
H_2O	8.26
F	.06
	99.81

PYROPHYLLITE.

A. Compact, white. From Deep River, N. C. Analysis by George Steiger.
B. Radiated. From East Tres Cerritos, Cal. Analysis by H. C. McNeil.

	A	B
SiO_2	64.73	6
Al_2O_3	29.16	2
Fe_2O_3	.49	
MgO	Trace.	N
H_2O-		
H_2O, ignition	5.35	
TiO_2	.73	Tr
	100.46	9

BEMENTITE.

From the Trotter mine, Franklin Furnace, N. J., collected by C. Palache. Analy by G. Steiger.

SiO_2	38.36
Al_2O_3	.96
Fe_2O_3	.71
FeO	4.94
MgO	3.35
CaO	.62
MnO	39.22
ZnO	2.93
H_2O-	.60
H_2O+	8.01
	99.70

MORENCITE.

Described as a new mineral from the Arizona Central mine, Morenci, Ariz., by Lin gren and Hillebrand in Bull. 262, p. 49. Analysis by W. F. Hillebrand.

SiO_2	45.74
Al_2O_3	1.98
Fe_2O_3	29.68
FeO	.83
CaO	1.61
MgO	3.99
K_2O	.20
Na_2O	.10
H_2O at 105°	8.84
H_2O at 150°	.12
H_2O below redness	4.27
H_2O at red heat	.69
FeS_2	.66
P_2O_5	.18
TiO_2, MnO, CuO	Traces.
	98.89

BOLE.

From South Table Mountain, Golden, Colo. Described by Cross and Hillebra in Bull. 20. Analyses by W. F. Hillebrand.

A. Dark brown.

B. Light brown.

	A	B
SiO_2	42.63	46.17
Al_2O_3	18.76	22.03
Fe_2O_3	11.88	4.64
CaO	2.59	2.30
MgO	3.39	2.42
K_2O	.35	[a] 2.06
Na_2O	.24	
H_2O	20.21	20.38
	100.05	100.00

[a] By difference.

THAUMASITE.

Collected by B. S. Butler at the Old Hickory mine, Frisco district, Utah. Analysis by W. T. Schaller. Described by Butler and Schaller in Am. Jour. Sci., 4th ser., vol. 31, p. 131. Sp. gr. 1.84.

SiO_2	10.14
SO_3	12.60
CO_2	6.98
CaO	26.81
H_2O	42.97
$(Al, Fe)_2O_3$	.20
MgO	.23
Alkalies	Traces.
P_2O_5	Trace.
	99.93

VIII. TITANATES AND TITANO-SILICATES.

ILMENITE.

From the peridotite dike of Elliott County, Ky. Described by Diller in Bull. 38. Analysis by T. M. Chatard.

TiO_2	49.32
SiO_2	.76
Al_2O_3	2.84
Cr_2O_3	.74
Fe_2O_3	9.13
FeO	27.81
MnO	.20
CaO	.23
MgO	8.68
Alkalies	.19
P_2O_5	Trace.
Ignition	.20
	100.10

ARIZONITE.

New species from 25 miles southeast of Hackberry, Ariz. Analyzed by Chase Palmer and described by him in Am. Jour. Sci., October, 1909. The following analysis shows the mineral to be a ferric metatitanate:

SiO_2	1.02
FeO	.80
Fe_2O_3	38.38
TiO_2	58.26
H_2O-	.18
H_2O+	1.02
Insoluble	.56
	100.22

XANTHITANE.

From Green River, Henderson County, N. C. Alteration product of titanite. Analyzed by L. G. Eakins and described in Bull. 60. Sp. gr., 2.941 at 24°. Material dried at 100°.

TiO_2	61.54
SiO_2	1.76
Al_2O_3	17.59
Fe_2O_3	4.46
CaO	.90
MgO	Trace.
P_2O_5	4.17
H_2O	9.92
	100.34

TITANITE.

Pale-yellow, semitranslucent. From the waterworks tunnel, Washington, D. C. Occurs embedded in prochlorite. Analysis by F. W. Clarke. Sp. gr., 3.452.

TiO_2	40.82
SiO_2	30.10
MnO	Trace.
CaO	28.08
MgO	.40
Ignition	.54
	99.94

TSCHEFFKINITE.

From Bedford County, Va. Analyzed by L. G. Eakins and described by him in Bull. 90.

A. Lustrous portion. Sp. gr., 4.33 at 27°.

B. Dull portion. Sp. gr., 4.38 at 22.2°.

	A	B
TiO_2	18.78	18.99
SiO_2	20.21	21.49
Ta_2O_5	.08	.08
ZrO_2	Trace?	Trace?
ThO_2	.85	.75
$(Y, Er)_2O_3$	1.82	1.64
$(La, Di)_2O_3$	19.72	17.16
Ce_2O_3	20.05	19.08
Al_2O_3	3.60	3.65
Fe_2O_3	1.88	2.89
FeO	6.91	5.92
CaO	4.05	5.24
MgO	.55	.48
Na_2O	.06	.04
H_2O	.94	2.06
	99.50	99.47

ASTROPHYLLITE.

From St. Peters Dome, near Pikes Peak, Colo. Analyzed by L. G. Eakins and described by him in Bull. 90.

TiO_2	11.40
SiO_2	35.23
ZrO_2	1.21
Ta_2O_5	.34
Fe_2O_3	3.73
Al_2O_3	Trace.
FeO	29.02
MnO	5.52
CaO	.22
MgO	.13
K_2O	5.42
Na_2O	3.63
H_2O	4.18
	100.03

IX. COLUMBO-TANTALATES.

MANGANO-TANTALITE.

From the Catharina mine, Pala, Cal. Analysis by W. T. Schaller.

$(Cb, Ta)_2O_5$	79.39
MnO	14.87
FeO	1.72
Gangue (by difference)	4.02
	100.00

Another mangano-tantalite from Mount Apatite, Auburn, Maine, is described by Schaller in Bull. 490, p. 96. An incomplete analysis gave $(Cb, Ta)_2O_5$, 85.35 per cent; FeO, 0.15 per cent; and MnO, 14.49 per cent by difference.

STRÜVERITE.

From the Etta claim, near Keystone, S. Dak.

Described by F. L. Hess and R. C. Wells in Am. Jour. Sci., 4th ser., vol. 31, p. 432, analysis by Wells.

TiO_2	47.8
Ta_2O_5	34.8
Cb_2O_5	6.2
FeO	7.3
SnO_2	1.3
SiO_2	2.0
H_2O	.4
	99.8

SAMARSKITE.

A mineral near samarskite, from Devils Head Mountain, near Pikes Peak, Colo. Analyzed by W. F. Hillebrand and described in Bulletin 55.

A. Pitch-black variety, streak dirty brown. Sp. gr., 6.18 at 22°.

B. Black, streak salmon-colored. Sp. gr., 6.12 at 25°.

C. Altered variety. Sp. gr., 5.45 at 16°.

	A	B	C
Ta_2O_5	27.03	28.11	19.34
Cb_2O_5	27.77	26.16	27.56
WO_3	2.25	2.08	5.51
SnO_2	.95	1.09	.82
ZrO_2	2.29	2.60	[a] 3.10
UO_2	4.02	4.22	....
UO_3	....	....	6.20
ThO_2	3.64	3.60	3.19
Ce_2O_3	.54	.49	.41
$(La, Di)_2O_3$	1.80	2.12	1.44
Er_2O_3	10.71	10.70	9.82
Y_2O_3	6.41	5.96	5.64
Fe_2O_3	8.77	8.72	8.90
FeO	.32	.35	[b] .39
MnO	.78	.75	.77
ZnO	.05	.07	
PbO	.72	.80	1.07
CaO	.27	.33	1.61
MgO	....	....	.11
K_2O	.17	.13	.36
$(Na, Li)_2O$	.24	.17	
H_2O	1.58	1.30	3.94
F	(?)	(?)	(?)
	100.31	99.75	100.18

[a] With TiO_2.

[b] Or 0.74 UO_2.

X. BORATES.

COLEMANITE.

A. Transparent crystal, ordinary type, Death Valley, Cal.
B, C. Bladelike crystals, Death Valley.
D. Priceite, Curry County, Oreg.
E. Pandermite, Island of Panderma, Black Sea.
Analyses by J. E. Whitfield, with details in Bull. 55.

	A	B	C	D	E
B_2O_3	50.70	49.56	49.62	48.44	48.63
CaO	27.31	27.36	27.40	32.15	32.16
MgO	.10	.25	.26	....	....
H_2O	21.87	22.66	22.70	19.42	19.40
SiO_2	....	.44	.47	....	....
	99.98	100.27	100.45	100.01	100.19

INYOITE AND MEYERHOFFERITE.

Two new borates from the Mount Blanco deposit, Furnace Creek, Death Valley, Cal. Related to and associated with colemanite. Both minerals form a single crystal, the unaltered center being inyoite, and the altered, but definite surface, meyerhofferite. Analyses and description by W. T. Schaller.

A. Inyoite. $2 CaO.3B_2O_3.13H_2O$.
B. Crystalline meyerhofferite. $2 CaO.3B_2O_3.7 H_2O$.
C. Powdery meyerhofferite.

	A	B	C
CaO	20.5	25.6	25.45
B_2O_3	[a] 37.2	[a] 45.6	46.40
H_2O-	26.1	.3	1.01
H_2O+	16.2	28.5	27.75
	100.0	100.0	100.61

[a] By difference.

ULEXITE.

From Rhodes Marsh, Esmeralda County, Nev. Analysis by J. E. Whitfield, with description in Bull. 55.

B_2O_3	43.20
CaO	14.52
Na_2O	10.20
K_2O	.44
H_2O	29.46
SiO_2	.04
SO_3	.28
Cl	2.38
	100.52
O equivalent to Cl	.53
	99.99

LUDWIGITE.

A. From Morawitza, Banat, Hungary. Analysis by J. E. Whitfield, with description, in Bull. 55.

B. Same locality as A. Analysis by W. T. Schaller.

C. From Phillipsburg, Mont. Contains some admixed olivine. Analysis by Schaller.

	A	B	C
SiO_2	......	0.36	8.85
B_2O_3	12.04	[a] 17.02	13.48
Al_2O_3	......	......	1.81
Fe_2O_3	37.93	35.67	29.73
FeO	15.78	15.84	5.79
MnO	.16	......	......
MgO	30.57	28.88	39.04
H_2O-	3.62	.51	.90
H_2O+		.82	.97
CO_2	......	.90	.36
	100.10	100.00	100.93

[a] By difference.

HULSITE AND PAIGEITE.

Two new borates from Brooks Mountain, Seward Peninsula, Alaska. Collected by A. Knopf. Analyzed by W. T. Schaller. Final description by Schaller in Bull. 490, p. 8.

A. Hulsite; sp. gr., 4.31. Average of several analyses.

B, C. Paigeite; sp. gr., 4.78. Average of several analyses.

	A	B	C
FeO	27.71	40.82	35.02
MgO	4.29	2.04	2.12
CaO	9.11	4.13	8.79
Fe_2O_3	15.21	18.67	14.90
SnO_2	7.07	3.18	2.80
B_2O_3	9.20	9.10	6.94
SiO_2	[a] 8.78	[b] 5.96	3.10
Al_2O_3			2.34
H_2O			[b] 5.42
Insoluble	18.63	16.10	18.57
	100.00	100.00	100.00

[a] By difference. Includes some CO_2. [b] By difference.

WARWICKITE.

From Edenville, Orange County, N. Y. Somewhat contaminated by spinel, from which the warwickite could not be entirely freed. Analysis by J. E. Whitfield. (See Bull. 64.)

B_2O_3	18.96
TiO_2	18.68
SiO_2	1.16
Al_2O_3	9.44
FeO	14.23
CaO	.38
MgO	34.41
H_2O	2.80
	100.06

XI. NITRATES.

SODA NITER.

From the Leucite Hills, Wyo. Analysis by L. G. Eakins. The N_2O_5 was not determined directly, but calculated to satisfy Na_2O+K_2O.

Na_2O	32.09
K_2O	4.97
N_2O_5	61.58
CaO	.24
SO_3	.33
Cl	Trace.
H_2O	.68
	99.89

NITER.

A. From Utah, exact locality unknown. Analysis by T. M. Chatard.

B. From the Leucite Hills, Wyo. Analysis by L. G. Eakins, with the N_2O_5 calculated to satisfy the alkalies.

	A	B
Insoluble matter	12.12	....
K_2O	38.38	44.91
Na_2O	.12	.07
N_2O_5	44.30	51.49
SiO_2	.20	....
Al_2O_3		
CaO	1.43	1.09
MgO	Trace.	....
NaCl	.08	....
Cl	....	.09
SO_3	2.05	1.59
H_2O	1.24	.62
	99.92	99.86

XII. PHOSPHATES.

XENOTIME.

From the gold washings at Brindletown, N. C. Analyses by L. G. Eakins.

A. Green; sp. gr., 4.68 at 24.2°.

B. Brown; sp. gr., 4.46 at 24.4°.

	A	B
SiO_2	3.46	3.56
ZrO_2	1.95	2.19
UO_2	4.13	1.73
ThO_2	Trace.	Trace.
Al_2O_3	.77	1.57
Fe_2O_3	.65	2.79
$(La, Di)_2O_3$	.93	.77
$(Y, Er)_2O_3$[a]	56.81	55.43
CaO	.21	.19
P_2O_5	30.31	29.78
F	.06	.56
H_2O	.57	1.49
	99.85	100.06

[a] Molecular weight, 260.

APATITE.

Dark-green, massive apatite from the topaz locality at Stoneham, Maine. Analysis by J. E. Whitfield. See Bull. 27. Sp. gr., 3.27.

P_2O_5	40.36
CaO	47.60
MgO	6.08
FeO	1.44
H_2O	.11
Cl	.29
F	6.84
	102.72
Excess O	2.94
	99.78

LITHIOPHILITE AND ITS DERIVATIVES.

Lithiophilite from Pala, Cal., and a series of other phosphates derived from it by alteration. Analyzed by W. T. Schaller and described by him in P. P. 92. See also triplite below.

A. Lithiophilite.
B. Hureaulite.
C. Palaite, new species.
D. Salmonsite, new species.
E. Strengite.
F. Sicklerite, new species.

	A	B	C	D	E	F
P_2O_5	43.01	38.63	39.02	34.86	37.06	43.10
FeO	12.54	6.14	7.48	.13	None.	None.
MnO	30.06	39.29	40.87	37.74	None.	33.60
CaO	.38	1.08	1.77	1.06	.34	.20
Fe_2O_3	2.24	.99	.16	9.53	41.14	11.26
Mn_2O_3					2.36	2.10
H_2O-	.70			.43	.17	
H_2O+	1.35	12.46	10.43	15.30	19.05	1.71
Li_2O	3.73	Trace.	Trace.	None.	None.	3.80
Na_2O	4.97					Trace.
Insoluble	.43	1.58	.89	1.40	Trace.	4.18
	100.01	100.17	100.62	100.45	100.12	99.95
Specific gravity		3.13	3.14-3.20	2.88		3.45

TRIPLITE.

A. From Pala, Cal. Derived from lithiophilite. Analysis by W. T. Schaller. Sp. gr., 3.84.

B. From Reagan mining district, White Pine County, Nev. Described by F. L. Hess and W. F. Hunt in Am. Jour. Sci., 4th ser., vol. 36, p. 51.

	A	B
P_2O_5	31.12	31.84
FeO	3.32	1.08
MnO	51.86	57.03
Mn_2O_3	[a] 3.45	
CaO	3.38	2.86
MgO		1.21
H_2O-	.09	
H_2O+	.78	
F	8.27	7.77
Insoluble	.62	
	102.89	102.99
Less O	3.48	3.27
	99.41	99.72

[a] Admixed.

GRIPHITE.

A doubtful species from a tin mine near Rapid City, S. Dak. Analyzed by L. Eakins and described in Bull. 60.

P_2O_5	39.68	K_2O	Tr[illegible]
SiO_2	.43	H_2O	3[illegible]
Al_2O_3	8.74	CO_2	[illegible]
Fe_2O_3	2.36	F	2.[illegible]
FeO	1.97	Cl	[illegible]
MnO	29.13		100.[illegible]
CaO	6.72	Less O	1.[illegible]
MgO	Trace.		
Li_2O	.13		99.[illegible]
Na_2O	5.25		

AMBLYGONITE.

From Pala, San Diego County, Cal. Analysis by W. T. Schaller.

P_2O_5	48.83	H_2O	5.9[illegible]
Al_2O_3	33.70	F	2.2[illegible]
Fe_2O_3	.12		101.3[illegible]
MnO	.09	Less O	.9[illegible]
MgO	.31		
Li_2O	9.88		100.4[illegible]
Na_2O	.14		

FREMONTITE.

New species, first described by W. T. Schaller under the name of natramblygonite. See Bull. 509, p. 101. From 4 miles west of Canon City, Colo. Analysis by Schaller.

P_2O_5	44.35
Al_2O_3	33.59
Li_2O	3.21
Na_2O	11.23
K_2O	.14
H_2O+	4.78
F	5.63
	102.93
Less O	2.37
	100.56

DUFRENITE(?).

Two samples of a fibrous phosphate from Grafton, N. H. Near dufrenite but uncertain. Analyses by W. T. Schaller.

	A	B
P_2O_5	32.40	31.87
Fe_2O_3	39.77	47.44
FeO	6.98	3.69
MnO	.45	5.51
CaO	5.71	.99
MgO	3.48	.12
H_2O	11.53	10.31
	100.32	99.93

PURPURITE AND HETEROSITE.

Two phosphates, one of manganese and the other of iron, which usually occur more or less commingled. See Schaller, Bull. 490, p. 72.

A. Purpurite, from Faries mine, Kings Mountain, N. C. Described as a new species by L. C. Graton and W. T. Schaller, Am. Jour. Sci., 4th ser., vol. 20, p. 146.

B. Heterosite, from Hill City, S. Dak. Analyses by Schaller.

	A	B
P_2O_5	47.30	43.45
Mn_2O_3	29.25	12.08
Fe_2O_3	15.89	38.36
CaO	1.48	1.37
MgO	....	Trace.
Li_2O	Present.	Trace.
Na_2O	.84	Trace.
H_2O	5.26	4.82
Insoluble in HCl	.52	.19
	100.54	100.27

EVANSITE.

A. From near Goldburg, Idaho.
B. From Columbiana, Ala. Analyses by W. T. Schaller.

	A	B
P_2O_5	19.14	[a]21.70
Al_2O_3	34.48	38.33
Fe_2O_3	5.49	....
CaO	4.32	1.03
MgO	Trace.	.75
H_2O	36.96	38.19
	100.39	100.00

[a] By difference. Determination lost.

VARISCITE.

From Lucin, Utah. Analyzed by W. T. Schaller and described by him in Bull. 509, p. 48.

Al_2O_3	32.40
P_2O_5	44.73
H_2O	22.68
V_2O_3	.32
Cr_2O_3	.18
Fe_2O_3	.06
	100.37

TURQUOISE.

Analyses A to C, by F. W. Clarke, represent turquoise from Los Cerrillos, N. Mex. Described by Clarke and Diller in Bull. 42.

A. Bright blue, faintly translucent in thin splinters.

B. Pale blue, with a slight greenish cast. Opaque and earthy in texture. Sp. gr. 2.805.

C. Dark green, opaque.

D. Crystallized turquoise from near Lynch Station, Campbell County, Va. Analyzed by W. T. Schaller and described by him in Bull. 509.

	A	B	C	D
P_2O_5	31.96	32.86	28.63	34.13
SiO_2	1.15	.16	4.20	....
Al_2O_3	39.53	36.88	37.88	36.50
Fe_2O_3		2.40	4.07	.21
CuO	6.30	7.51	6.56	9.00
CaO	.13	.38	Undet.	....
H_2O	19.80	19.60	18.49	20.12
	98.87	99.79	99.83	99.96

PHOSPHORITE.

Although a very large number of analyses of phosphate rock have been made in the laboratory of the Survey, only a few of them are even approximately complete. These few may properly be recorded here, despite the fact that "phosphorite" is not a definite mineral species. All are by George Steiger. Analyses A to D are of rock from Florida.

A. New Sunnyside, Taylor County.
B, C. Luraville district, Suwanee County.
D. Albion district, Levy County.

	A	B	C	D
SiO_2	3.44	10.63	5.36	10.51
TiO_2	.13	.86	.26	.58
Al_2O_3	1.49	12.42	5.41	21.17
Fe_2O_3	1.43	2.90	2.86	3.10
CaO	48.81	30.93	42.13	23.95
MgO	.23	.29	.47	.15
P_2O_5	35.93	30.35	33.37	25.38
CO_2	2.71	1.72	2.15	2.14
F	2.55	1.95	2.10	1.42
K_2O	Trace.	.20	None.	.40
Na_2O	Trace.	.27	None.	
SO_3	.10	.13	.09	.15
H_2O-	.90	1.27	1.84	1.27
H_2O+	1.98	7.69	4.76	10.35
C, organic	....	.12	.18	.22
	99.70	101.73	100.98	100.79
Less O	1.05	.82	.88	.60
	98.65	100.91	100.10	100.19

E. From 2½ miles east of Cokeville, Wyo.
F. Dunellen lode, 8 miles southwest of Sage, Utah.
G. Three miles west of Devils Slide, Utah.
H. Eight miles east of Georgetown, Idaho.

	E	F	G	H
Insoluble	2.62	1.82	9.40	10.00
SiO_2	.46	.30	Undet.	None.
Al_2O_3	.97	.50	.90	.89
Fe_2O_3	.49	.26	.33	.73
MgO	.35	.22	.26	.28
CaO	48.91	50.97	46.80	45.34
Na_2O	.97	2.00	2.08	1.10
K_2O	.34	.47	.58	.48
H_2O-	1.02	.48	.61	1.04
H_2O+	1.34	.57	.75	1.14
CO_2	2.42	1.72	2.14	6.00
P_2O_5	33.61	36.35	32.05	27.32
SO_3	2.16	2.98	2.34	1.59
F	.40	.40	.66	.60
Cl	Trace.	Trace.	Trace.	Trace.
	95.97	99.04	98.90	96.51
Less O	.16	.16	.27	.24
	95.81	98.88	98.63	96.27

TiO_2 absent. Organic matter present, undetermined.

XIII. VANADATES.

DESCLOIZITE.

A. From the Mayflower mine, Bald Mountain mining district, Beaverhead County, Mont. Yellow, friable, not crystallized.

B. From the Commercial mine, Georgetown, N. Mex. Brilliantly crystallized. Analyses by W. F. Hillebrand, with description in Bull. 64.

	A	B
	20.80	20.44
	.32	.94
	.27	.26
	.18	1.01
	55.93	54.01
	15.94	17.73
	1.15	1.05
	.70	.07
	.10	.04
	.06	.03
	4.37	2.45
	....	.04
	99.82	100.07

CUPRODESCLOIZITE.

m the Shattuck mine, Bisbee, Ariz. Received from Philip D. Wilson. l by R. C. Wells.

m the Lucky Cuss mine, Tombstone, Ariz. Analyzed by W. F. Hillebrand, ribed in Bull. 64. Sp. gr., 5.88 at 19°.

	A	B
	0.17	....
	....	0.80
	55.64	57.00
	17.05	11.21
	.31	4.19
	21.21	19.79
	1.33	1.10
	.24	.19
	.50	....
	....	.82
	....	Trace.
	....	1.01
	....	.04
	....	.10
	....	.17
	3.57	2.50
	....	.07
	100.02	98.99

PUCHERITE.

Pala, Cal. Analyzed by W. T. Schaller and described by him in Jour. Am. oc., vol. 33, p. 162.

cherite, at first supposed to be bismuth ocher.

nixture of pucherite with bismuth hydroxide.

nalyses were made on very scanty material.

	A	B
	66.14	64.43
	25.80	12.11
	.21	.32
	1.16	3.67
	7.37	19.90
	100.68	100.43

CARNOTITE.

From Montrose County, Colo. See memoir by Hillebrand and Ransome, Am. Jour. Sci., 4th ser., vol. 10, p. 120.

A, B, C. From Copper Prince claim, Roc Creek.

D, E. From Yellow Boy claim, La Sal Creek.

Analyses by W. F. Hillebrand.

	A	B	C	D	E
V_2O_5	18.35	18.49	15.76	17.80	18.05
As_2O_5	.25	Trace.	None.	None.	None.
P_2O_5	.33	.80	.40	Trace.	.05
SiO_2		.15	.13	5.05	.20
TiO_2	.10	.03	(?)		(?)
CO_2	.33	.56	None.		None.
SO_3	.12		.18		None.
UO_3	52.25	54.89	47.42	52.28	54.00
MoO_3	.23	.18	.18	Undet.	.05
CrO_3	Trace.				
Fe_2O_3	1.77	.21	.72	3.36	.42
Al_2O_3	1.08	.09	.08	Undet.	.29
PbO	.25	.13	.18	Undet.	.07
CuO	.20	.15	.22		Trace.
CaO	2.85	3.34	2.57	1.85	1.86
SrO		.02	(?)		Trace.
BaO	.72	.90	.65	3.21	2.83
MgO	.20	.22	.24	.17	.14
Li_2O	None.	Trace.	(?)	Trace.	Trace.
Na_2O	.09	.14	.07	.07	.13
K_2O	6.73	6.52	6.57	5.32	5.46
H_2O-	2.59	2.43	1.85	4.52	3.16
H_2O+	3.06	2.11	2.79	3.87	2.21
Insoluble	8.34	7.10	19.00		10.33
	99.84	98.46	99.01	97.50	99.25

XIV. ARSENATES.

OLIVENITE.

From the American Eagle mine, Tintic mining district, Utah. Described by W. F. Hillebrand in Bull. 20. Analysis by Hillebrand.

As_2O_5	40.05
P_2O_5	.06
CuO	55.40
Fe_2O_3	.25
CaO	.16
ZnO	Trace.
H_2O	3.39
Quartz	.40
	99.71

ERINITE.

From the Mammoth mine, Tintic district, Utah. Described by Hillebrand and Washington in Bull. 55. Analyses by W. F. Hillebrand.

	A	B
As_2O_5	33.53	31.91
P_2O_5	.10	
CuO	57.67	57.51
ZnO	1.06	.59
CaO	.32	.51
MgO	Trace.	Trace.
Fe_2O_3	.14	.20
H_2O	7.22	9.15
	100.04	99.87

CLINOCLASITE.

From the Mammoth mine, Tintic district, Utah. Described by Hillebrand and Washington in Bull. 55. Analyses by W. F. Hillebrand. Sp. gr., 4.38 at 19°.

	A	B
As_2O_5	29.59	29.60
P_2O_5	.05	[a] .05
SiO_2	.06	[a] .06
CuO	62.34	62.54
ZnO	.06	.04
Fe_2O_3	.12	.12
H_2O	7.73	7.72
	99.95	100.13

[a] Assumed the same as in A.

CONICHALCITE.

From the American Eagle mine, Tintic district, Utah. Analysis by W. F. Hillebrand, with description in Bull. 20.

As_2O_5	39.94	Fe_2O_3	0.36
P_2O_5	.14	Ag	.30
CO_2 (by difference)	.97	H_2O	5.52
CuO	28.68	Quartz	.90
ZnO	2.86		100.00
CaO	19.79		
MgO	.54		

TYROLITE.

From the Mammoth mine, Tintic district, Utah. Described by Hillebrand and Washington in Bull. 55. Analyses by W. F. Hillebrand. Sp. gr., 3.27 at 20.5°.

	A	B
As_2O_5	28.78	26.22
P_2O_5	Trace.	Trace.
CuO	45.22	46.38
ZnO	.04	Trace.
CaO	6.84	6.69
MgO	.05	.04
H_2O	17.26	17.57
SO_3	(?)	2.27
	98.19	99.17

CHENEVIXITE.

From the American Eagle mine, Tintic district, Utah. Analyzed by W. F. Hillebrand and described in Bull. 20.

As_2O_5	35.14
CuO	26.31
CaO	.44
MgO	.16
Fe_2O_3	27.37
Al_2O_3	.66
H_2O	9.33
Quartz	.40
	99.81

MIXITE.

From the Mammoth mine, Tintic district, Utah. Described by Hillebrand and Washington in Bull. 55. Analysis by W. F. Hillebrand.

As_2O_5	28.79
P_2O_5	.06
SiO_2	.42
CuO	43.89
ZnO	2.70
CaO	.26
Bi_2O_3	11.18
Fe_2O_3	.97
H_2O	11.04
	99.31

SCORODITE.

An incrustation on hot-spring deposits, from Joseph's Coat Spring, Broad Creek, Yellowstone Park. Analyzed by J. E. Whitfield and described in Bull. 55.

As_2O_5	46.48
Fe_2O_3	33.29
H_2O	15.50
SiO_2	4.35
SO_3	.84
	100.46

LISKEARDITE ?.

An aluminum arsenate from the Sunshine mine, Mercur district, Utah. Received from Victor Heikes. Analysis by W. F. Hillebrand. Probably liskeardite, with admixed calcium arsenate. See F. W. Clarke, Jour. Wash. Acad., vol. 2, p. 516.

SiO_2	7.08	CO_2	0.88
Al_2O_3	26.46	F	.21
Fe_2O_3	.64	Cl	Trace.
CaO	10.29	H_2O	17.23
SrO	2.10		100.04
MgO	Trace.	Less O	.09
$(K,Na)_2O$	.12		99.95
As_2O_5	33.82		
P_2O_5	.94		
SO_3	.27		

XV. ANTIMONATES.

SCHNEEBERGITE.

From Schneeberg, Tyrol. Analysis by W. T. Schaller. Sp. gr., 5.41.

Sb	57.40
O	15.19
FeO	8.51
MnO	None.
CaO	17.42
Na_2O	.10
H_2O	1.67
Gangue	.30
	100.59

ATOPITE AND ROMEINE.

Two minerals which seem to be identical, although the original atopite from Sweden may be different.

Analyses by W. T. Schaller.

A. Atopite, Minas Geraes, Brazil. Sp. gr., 5.04.

B. Romeine, St. Marcel, Piedmont. Sp. gr., 5.07.

	A	B
Sb	56.02	56.15
O	18.70	18.57
FeO	1.29	1.12
MnO	2.62	6.27
CaO	14.81	15.81
Na_2O	5.08	.81
H_2O	1.12	1.39
	99.64	100.12

BINDHEIMITE.

From a claim near the Bertrand mine, Secret Canyon, Nev. Analyzed by W. F. Hillebrand and described in Bull. 20. Sp. gr., 5.01 at 19°, after correction for admixed quartz and cerusite.

Sb_2O_5	35.20
PbO	49.50
CuO	.58
ZnO	.18
CaO	.66
MgO	.03
K_2O	.14
Na_2O	.21
Fe_2O_3	.09
Ag	.29
CO_2	3.35
H_2O	5.86
Quartz	4.59
	100.68

XVI. SULPHATES AND TELLURITES.

ANHYDRITE.

A. From 2½ miles east of Gypsum, Colo. Analysis by J. G. Fairchild.

B. From Newhouse, Utah. Approximate analysis by W. T. Schaller.

	A	B
CaO	40.61	39.84
SO_3	56.82	55.89
H_2O	1.87	3.57
SiO_2	Trace.	....
$(Al, Fe)_2O_3$	Trace.	....
Organic matter	.46	....
	99.76	99.30

GYPSUM.

A. From Hillsboro, New Brunswick. Analysis by George Steiger.
B. From the Western Plaster Works, Alabaster, Mich. Analysis by George Steiger.
C. From east of Cascade, Black Hills, S. Dak. Analysis by Steiger.
D. From Rico-Aspen mine, Rico district, Colorado. Analysis by W. F. Hillebrand.
E, F. From Nephi, Utah. Analyses by E. T. Allen. Some anhydrite must be present.

	A	B	C	D	E	F
SO_3	46.18	46.18	45.45	45.07	48.14	3[illegible].53
CO_2	......	......	.85	1.54	.65	[illegible].73
Cl	Trace.	.03	......	......	Trace.	.04
SiO_2	......	......	.10	.51	......	—
TiO_2	......	......	......	Trace.	......	—
Al_2O_3	.10	.08	.12	.03	......	.14
Fe_2O_3			......	.09	......	
CaO	32.37	32.33	32.44	32.49	35.29	3[illegible].46
SrO	......	......	......	.10	......	—
MgO	Trace.	.05	.33	.92	Trace.	.24
Na_2O	.10	.14	......	Trace.	......	.07
K_2O			......	......	......	.19
H_2O	20.94	20.96	20.80	19.67	15.88	1[illegible]
Insoluble	.10	.05	......	......	......	.45
Organic matter	......	......	......	Present.	......	—
	99.79	99.82	100.09	100.42	99.96	9[illegible].54

G. Gypsite, Watonga, Okla. Analysis by Chase Palmer.
H. From west point of Sierra Nacimiento, N. Mex. Analysis by W. T. Schaller.
I, J. From Lost Hills, San Joaquin Valley, Cal. Analyses by R. C. Wells.

	G	H	I	J
SO_3	40.51	46.61	40.7	40.8
CaO	29.54	34.24	29.5	29.9
MgO	.23	......	None.	None.
Al_2O_3	2.11	......	1.7	1.4
Fe_2O_3		......	.4	.3
Na_2O	.49	......	1.2	2.0
K_2O	......	......	.6	.5
H_2O	18.58	18.89	19.1	19.4
CO_2	.29	......	.7	None.
Cl	Present.	......	None.	None.
SiO_2	7.91	......	5.3	6.1
Insoluble	......	.18	......	......
	99.66	99.92	99.2	100.4

The following gypsums from Colorado were received from E. F. Burchard. Partial analyses by J. G. Fairchild.

K. From one-half mile south of Gypsum.
L. From 8 miles east of Gypsum.
M. From Eagle.
N. From Ruedi.

	K	L	M	N
SiO_2	0.24	3.90	4.38	0.05
$(Al, Fe)_2O_3$	.18	2.29	1.86	.13
CaO	32.60	34.56	30.74	32.94
SO_3	43.80	32.61	40.40	44.23
H_2O	19.62	14.54	18.62	20.30
Organic matter	1.11	2.99	.75	.25
	97.55	90.89	96.75	97.90

O, P. From 12 miles from Castle Dale, Utah. O, Fullers Bottom; P, Horn Silver Gulch. Received from C. T. Lupton. Analyses by J. G. Fairchild.

Q. From Waterloo Mountain, Montpelier, Idaho. Received from R. W. Richards. Analysis by W. C. Wheeler.

	O	P	Q
CaO	32.49	32.47	31.40
SO_3	45.88	45.63	41.13
H_2O	20.58	20.54	18.39
SiO_2	......	......	4.14
Al_2O_3	......	......	.89
Fe_2O_3	Trace.	Trace.	.10
MgO	......	......	.99
Cl	.39	.32	......
CO_2	......	......	2.33
	99.34	98.96	99.37

BARITE.

Barite nodule from about 7½ miles west of New Idria, Cal. Analysis by G. Steiger.

BaO	57.19
SO_3	29.41
SiO_2	7.51
Al_2O_3	2.92
Fe_2O_3	.41
MgO	.35
CaO	.46
P_2O_5	Trace.
	98.25

BOOTHITE.

From Campo Seco, Cal. Analysis by W. T. Schaller.

SO_3	27.25
CuO	26.13
FeO	.81
MgO	.64
H_2O-	36.76
H_2O+	4.91
Insoluble	3.96
	100.46

PISANITE.

From Bingham, Utah. Analysis by W. F. Hillebrand.

SO_3	28.52
CuO	12.60
FeO	14.13
ZnO	.10
H_2O	44.92
	100.27

BROCHANTITE.

From the United Verde mine, Jerome, Ariz. Analysis by W. F. Hillebrand.

SO_3	16.75
CuO	69.45
PbO	.04
Fe_2O_3 (from gangue)	.28
CaO	Trace.
H_2O	12.05
P_2O_5	Trace.
CO_2	.71
Insoluble	.70
	99.98

ANTLERITE.

From the Antler mine, Yucca Station, Mohave County, Ariz. Described by Hillebrand as a new species in Bull. 55. Sp. gr., 3.93 at 16°, corrected for gangue. Analyses by W. F. Hillebrand.

A, B. First lot received.

C. Later sample.

	A	B	C
SO_3	18.78	18.48	20.11
CuO	62.48	62.69	63.26
ZnO	.27	.27	.04
CaO	.06	.05	.04
MgO	.03	.03	....
Al_2O_3, Fe_2O_3	.14	.12	.15
SiO_2	.06	Undet.	.05
H_2O	10.21	10.18	10.05
Insoluble gangue	8.01	8.02	6.27
	100.04	99.84	99.97

BLOEDITE.

Large crystals from Soda Lake, Carrizo Plain, Cal. Analysis by W. T. Schaller.

H_2O	21.37
MgO	11.93
Na_2O	18.26
SO_3	48.11
	99.67

PICRALLUMOGENE.

From near Las Vegas, N. Mex. Analysis by W. F. Hillebrand.

SO_3	37.51
Al_2O_3	9.71
MnO	.06
MgO	6.75
Na_2O	2.09
K_2O	.23
H_2O	43.75
	100.15

HALOTRICHITE.

A. From the headwaters of Gila River, Grant County, N. Mex., about 40 miles north of Silver City. Analyzed by F. W. Clarke and described in Bull. 9.

B. From Alum Creek, N. Mex. Possibly the same locality as A. Analysis by W. T. Schaller.

	A	B
SO_3	37.19	35.25
Al_2O_3	7.27	11.77
FeO	13.59	7.94
H_2O	40.62	45.09
Insoluble	.50	....
	99.17	100.05

ALUNOGEN.

A. From the headwaters of Gila River, Grant County, N. Mex., about 40 miles north of Silver City. Analyzed by F. W. Clarke and described in Bull. 9. Color, pinkish.

B. From the calcite spring, Yellowstone Park. Fine, white, silky fibers. Analysis by J. E. Whitfield.

C. From the Grand Canyon, Yellowstone Park. Analysis by J. E. Whitfield.

	A	B	C
SO_3	34.43	40.65	38.22
Al_2O_3	15.52	15.72	16.80
Fe_2O_3		Trace.	Trace.
CaO		Trace.	None.
MgO		1.53	.18
K_2O			.01
Na_2O			.63
H_2O	42.56	41.81	43.64
SiO_2		.09	1.38
Insoluble	7.62		
	100.13	99.80	100.86

COPIAPITE.

A. From the Redington mine, Knoxville, Cal.

B. From Sulphur Bank, Lake County, Cal.

Analyses by W. H. Melville. Description by Melville and Lindgren in Bull. 61.

	A	B
SO_3	39.97	38.82
Al_2O_3		.37
Fe_2O_3	26.54	26.79
FeO	.46	3.28
MnO	.21	Trace.
CaO		.25
MgO	3.06	.16
H_2O	30.43	29.58
Residue		.75
	100.67	100.00

KNOXVILLITE.

From the Redington mine, Knoxville, Cal. Described as a new species by Melville and Lindgren in Bull. 61. Analysis by W. H. Melville.

SO_3	35.91
Cr_2O_3	7.41
Al_2O_3	4.83
Fe_2O_3	15.36
FeO	3.81
NiO	.83
MgO	3.22
H_2O-	9.30
H_2O+	17.60
Residue	1.73
	100.00

REDINGTONITE.

From the Redington mine, Knoxville, Cal. Described as a new species by Melville and Lindgren in Bull. 61. Analysis by W. H. Melville. Sp. gr., 1.761.

SO_3	35.35
Cr_2O_3	7.51
Al_2O_3	5.14
Fe_2O_3	.19
FeO	4.58
NiO	1.00
MnO	Trace.
MgO	1.85
H_2O-	27.09
H_2O+	14.34
Residue	3.46
	100.51

ALUNITE.

A. From Knickerbocker Hill, Custer County, Colo. Analysis by L. G. Eakins.

B, C. From Calico Peak, Rico Mountains, Colo. Analyses by G. Steiger. Described by Whitman Cross in 21st Ann., pt. 2, p. 94.

D, E. From Marysvale, Utah. D, crystalline; E, massive. Analyses by W. T. Schaller. Described by B. S. Butler and H. S. Gale in Bull. 511.

F. From Tres Cerritos Buttes, southwest of Indian Gulch, Mariposa County, Cal. Analysis by William Valentine.

	A	B	C	D	E	F
SO_3	35.91	35.24	37.92	38.34	36.54	38.50
Al_2O_3	38.91	42.35	37.66	37.18	34.40	38.05
Na_2O	4.32	4.02	2.12	.33	.56	2.78
K_2O	4.03	3.27	6.77	10.46	9.32	4.48
H_2O-	13.03	.13	.06	.09	.11	11.92
H_2O+		11.99	13.03	12.90	13.03	
SiO_2	2.82	2.54	1.79	.22	5.28	2.64
TiO_2						.40
CaO	.35	.08	.38			.55
MgO	Trace.					Trace.
P_2O_5				.58	.50	Trace.
Fe_2O_3				Trace.	Trace.	.23
	99.37	99.62	99.73	100.10	99.79	99.55

JAROSITE.

A. From Black Iron mine, Eagle County, Colo.

B. From Pigeon mine, Rico district, Colo.

Analyses by W. F. Hillebrand.

	A	B
SO_3	30.72	28.20
Fe_2O_3	46.37	43.81
PbO	1.80	
MgO	Trace.	Trace.
CaO		.06
K_2O	8.14	7.44
Na_2O	.27	.08
H_2O	11.40	11.64
Al_2O_3		1.00
P_2O_5		.33
As_2O_5	.51	
SiO_2	.72	7.35
	99.93	99.91

NATROJAROSITE.

From Soda Springs Valley, on road from Sodaville to Vulcan copper mine, Nev. Described by Hillebrand and Penfield in Am. Jour. Sci., 4th ser., vol. 14, p. 211. Analysis by W. F. Hillebrand. Sp. gr., 3.18 at 30.5°.

SO_3	30.96
Fe_2O_3	50.98
CaO	.04
K_2O	.35
Na_2O	6.03
H_2O-	.12
H_2O+	11.03
SiO_2	.23
As_2O_5	.20
	99.94

PLUMBOJAROSITE.

A. From Cooks Peak, N. Mex. Described as a new species by W. F. Hillebrand nd S. L. Penfield, in Am. Jour. Sci., 4th ser., vol. 14, p. 211. Analysis by Hillerand. Sp. gr., 3.668 at 30.5°.

B. From near Frisco, Beaver County, Utah. Described by B. S. Butler and W. T. haller in Am. Jour. Sci., 4th ser., vol. 32, p. 418.

C. From Lower Waterloo mine, Leadville, Colo. Analysis by Hillebrand.

D. From Morning Star mine, Leadville. Analysis by Hillebrand.

E. From Maid of Erin mine, Leadville. Analysis by Hillebrand. Samples D d E are mixtures of plumbojarosite and jarosite, with the latter predominating.

F. Ochreous ore, Ibex mine, Leadville. Probably an impure plumbojarosite, and erefore included here. Analysis by Hillebrand. When alumina, as kaolin, and ica are deducted, the remainder of the analysis gives very closely the composition plumbojarosite.

	A	B	C	D	E	F
O	19.84	18.32	19.50	8.27	4.27	13.32
O	.27					.89
O		.30				
O_3	42.37	42.11	44.40	42.98	46.70	31.08
O_3	.10		.23	.20		2.26
O	.21	.13	.37	.83	1.68	.29
O	.17	Trace.	.15	6.31	5.33	.55
O						Trace.
	27.06	27.59	25.07	27.81	30.53	20.81
O−	.02	9.16	8.99	10.12	10.54	.12
O+	9.54					7.29
O	.06			.64	.06	.05
O	.01				.06	Trace.
O_3					.08	.47
O_5			.39	.42	.46	
$_4$			.11	1.58	.08	.10
$_2$	.51	2.64	.36	.30		21.13
			.04	.26	.02	Trace.
			.075	.004	.005	.19
					Trace.	
	100.15	100.25	99.685	99.724	99.815	98.55

BEAVERITE.

A new species from the Horn Silver mine, near Frisco, Utah. Described by B. S. itler and W. T. Schaller in Am. Jour. Sci., 4th ser., vol. 32, p. 418. Analysis by haller.

Insoluble (mostly quartz)	10.06
CuO	9.70
PbO	29.44
Fe_2O_3	17.28
Al_2O_3	3.64
H_2O	9.02
SO_3	21.32
	100.45

HINSDALITE.

A new species from Golden Fleece mine, near Lake City, Colo. Described by E. S. ırsen and W. T. Schaller in Am. Jour. Sci., 4th ser., vol. 32, p. 251. Analysis by haller. Sp. gr., 3.64.

PbO	31.75
SrO	3.11
Al_2O_3	26.47
SO_3	14.13
P_2O_5	14.50
H_2O	10.25
	100.21

EMMONSITE.

A hydrous ferric tellurite from near Tombstone, Ariz. Analyzed partially by W. F. Hillebrand, and described by him as a new species in Proc. Colorado Sci. Soc., vol. 2, pt. 1, p. 21. The data relative to the composition of emmonsite are as follows:

	A	B	C	D
Te(Se)	59.77	59.15	59.05	59.14
Fe	14.00	14.06	14.90	14.20
ZnO	....	....	....	1.94
CaO	....	....	....	.56
H_2O	3.28	....	....	....

Another mineral, apparently emmonsite, from the W. P. H. mine, Cripple Creek, Colo., has also been analyzed by Hillebrand. A, B, C are partial analyses; D is the mean of all.

	A	B	C	D
TeO_2	70.83	71.80	70.20	70.71
Fe_2O_3	22.67	22.81	22.79	22.76
H_2O-	4.68	4.82	.21	.21
H_2O+			....	4.54
P_2O_5	....	.34	....	.34
Al_2O_3	....	.58	.54	.56
SiO_2, etc.[a]	....	....	.88	.88
	....	....	....	100.00

[a] By difference. Includes alkalies, and traces of magnesia, gold, and metals precipitable by H_2S.

XVII. MOLYBDATES, TUNGSTATES, AND URANATES.

POWELLITE.

A. From the Seven Devils mining district, Idaho. Analyzed by W. H. Melville, and described by him as a new mineral species in Bull. 90. Sp. gr., 4.526.

B. From Baringer Hill, Llano County, Tex., Ochreous, coating molybdenite. Sp. gr., 4.15.

C. From 2 miles south of Oak Springs, Nye County, Nev. Analyses B, C by W. T. Schaller.

	A	B	C
MoO_3	58.58	67.90	62.43
WO_3	10.28	....	....
Fe_2O_3	1.65	....	1.17
Al_2O_3	Trace.	....	....
CaO	25.55	27.46	26.44
MgO	.16	....	....
CuO	Trace.	....	....
SiO_2	3.25	....	6.80
MoS_2	....	1.50	
H_2O	....	[a]2.33	2.69
Insoluble	....	.88	....
	99.47	100.07	99.53

[a] By ignition.

KOECHLINITE.

From Schneeberg, Saxony. Originally supposed to be bismite. Analyzed by T. Schaller and identified as a new species, bismuth molybdate, Bi_2MoO_6. Aver- ge composition, after deducting admixed, insoluble gangue, as follows:

Bi_2O_3	77.1
MoO_3	22.4
H_2O	.2
	99.7

MOLYBDIC OCHER.

A. From Renfrew, Ontario.
B. From Westmoreland, N. H.
C. From Telluride, Colo.
D. From Hortense, Colo.
E. From California, exact locality unknown. Analyses by W. T. Schaller; A, C, d E on very little material.

	A	B	C	D	E
O_3	55.7	57.69	59.3	46.77	47.7
O_3	17.3	21.08	19.0	15.95	15.8
O	15.5	17.62	15.8	15.87	15.4
S_2	......	......	......	5.50	......
$_2$				16.51	......
olul le	9.4	4.66	[a] 5.9	......	24.0
	97.9	101.05	100.0	100.60	102.9

[a] By difference.

SCHEELITE.

Four samples from California, analyzed by R. C. Wells.
A. Sidney mine, near Randsburg.
B. Papoose mine, Atolia.
C, D. East Union mine, Atolia.

	A	B	C	D
O_3	78.27	77.81	75.42	70.12
O	19.82	18.67	18.28	17.98
$_2$	1.28	2.00	6.75	11.35
$l, Fe)_2O_3$	.37	.09	.01	.10
O	.38	None.	None.	None.
	100.12	98.57	100.46	99.55

HÜBNERITE.

A. From the Royal Albert vein, Uncompahgre District, Ouray County, Colo. nalyzed by W. F. Hillebrand and described by him in Bull. 20. Sp. gr., 7.177, at °.

B. From Patterson Creek, Lemhi County, Idaho. Analysis by W. T. Schaller.
C. From Oroville, Wash. Analysis by R. C. Wells. Sp. gr., 7.2.

	A	B	C
O_3	75.58	76.6	76.5
nO	23.40	21.4	18.5
O	.24	2.0	4.4
O	.13	......	.2
O_2	.62	......	.7
$_2O_5$(?)	.05	......	......
	100.02	100.0	100.3

WOLFRAM.

Analyses by R. C. Wells.
A. Hill City, S. Dak.
B. Oreville, S. Dak.
C. Germania mine, Deer Trail district, Washington.
D. Lost River, Alaska.

	A	B	C	D
WO_3	71.4	76.0	75.73	74.9
MnO	10.2	6.6	4.93	12.8
FeO	13.7	17.0	18.68	10.6
Fe_2O_3		....	.22	....
Al_2O_3		....		....
PbO	....	....	....	Trace.
SnO_2	....	....	....	.6
SiO_2	3.5	.9	.36	.9
CaO	.7	.2	None.	.3
MgO	None.	None.	None.	Trace?
H_2O	.3	....	....	....
	99.4	100.7	99.92	100.1

FERRITUNGSTITE.

A tungstic ocher from the Germania mine, Deer Trail mining district, Washington. Described as a new species by W. T. Schaller in Bull. 509, p. 83. Formula $Fe_2WO_6.6H_2O$. Analysis in duplicate by Schaller on very little material.

	1	2
WO_3	37.1	35.8
Fe_2O_3	26.6	27.3
H_2O	18.6	20.9
Insoluble	14.7	[16.0]
	97.0	100.0

URANINITE.

Analyses by W. F. Hillebrand. Discussed in Bulls. 78 and 90. In the original publications the gaseous constituent of uraninite was supposed to be nitrogen, as indeed it was in part. The discovery of helium, however, has shed new light upon the subject, and the analyses have been corrected accordingly.

A, B, C, D, E. Crystallized uraninite from Hale's quarry, Glastonbury, Conn. Nitrogen was certainly present in these specimens.

	A	B	C	D	E
UO_3	22.08	23.35	22.22	26.48	23.03
UO_2	59.13	58.01	59.31	57.43	59.93
ThO_2	9.57	9.78	10.31	9.79	11.10
CeO_2				.25	
ZrO_2?		....		....	
$(La, Di)_2O_3$		.46		.13	
$(Y, Er)_2O_3$				.20	
PbO	3.14	3.24	3.07	3.28	3.08
CaO	.08	....	Undet.	.08	.11
MgO	....	....	Undet.	....	....
Alkalies	....	....	Undet.	Trace.	....
H_2O	.97	Undet.	Undet.	.61	.43
He, etc	Undet.	Undet.	Undet.	Undet.	.34
Fe_2O_3	1.21	.33	.67	.40	.29
MnO	....	....	....	Trace.	....
SiO_2	1.06	....	.25	.16	.16
P_2O_5	....	....	....	....	.02
F	....	....	....	....	.04
Insoluble	.85	1.74	.42	.70	.89
Cb_2O_5	.96	....	....	....	....
	99.05	96.91	96.25	99.49	99.42
Specific gravity	9.139	9.051	....	9.587	9.622

Brilliantly crystallized, from Branchville, Conn.
ed uraninite, from the Flat Rock mine, Mitchell County, N. C.
e, from near Blackhawk, Colo.
Marietta, S. C.

	F	G	H	I	J	K	L
....	13.27	21.54	14.00	50.83	44.11	25.26	83.95
....	72.25	64.72	70.99	39.31	46.56	58.51	
....	....	....	....	....	....	Trace.	....
....	7.20	.33	6.52	....	....	7.59	.20
....		6.93		2.78	3.04	....	1.65
....	....	....	....	.26		.22	.19
....	....	....	....	.50		....	2.05
....	....	....	....	.20		....	6.16
....	4.35	4.34	4.35	4.20	4.53	.70	3.58
....	....	....	....	....	....	.44	....
....	....	....	....	Trace.	....	.32	....
....	.11	.28	.27	....	....	....	Trace.
....	.10	.07	(?)	....	....	.16	....
....	.18	.22	.30	.85	.23	.84	.41
....	....	....	.15	.30	.25	Trace?	Trace.
....	....	....				Trace?	Trace.
....	.68	.67	.68	1.21	Undet.	1.96	Undet.
....	Undet.	Undet.	.38	.05	Undet.	.02	Undet.
....	.03	.13	.20	.08	.13	2.79	....
....	....	....	....	(?)	....	.22	....
....	....	....	....	....	....	.43	....
....	....	....	....	....	....	.12	....
....	....	....	....	....	....	.24	....
....	.04	.14	1.40	.10	.06	....	.20
	98.21	99.37	99.24	100.67	98.91	99.82	98.39
....	9.733	9.560	9.348	8.086	9.492	8.068	....

ite, from Llano County, Tex.
what altered uraninite from Villeneuve, Province of Quebec, Canada.
e uraninite, from Johanngeorgenstadt, Saxony.

	M	N	O
....	20.89	34.67	22.33
....	44.17	41.06	59.30
....	6.69	6.41	None.
....	.34	(?)	
....	.34	.40	
....	2.36	1.11	
....	9.46	2.57	
....	.32	.39	1.00
....	10.08	11.27	6.39
....	1.48	1.47	3.17
....	.08	.10	Trace.
....	.46	.19	.50
....	.14	.10	.21
....	....	....	.20
....	....	....	.17
....	....	....	.31
....	....	.09	.75
....	....	....	.17
....	....	....	.09
....	....	....	.06
....	....	....	2.34
O_3........	....	....	.75
....	....	....	.19
....	1.47	.13	....
	98.28	99.96	97.93
y........	8.29	....	6.89

The following uraninites are all from Norway, and were analyzed for comparison with the American material.

P. Bröggerite from Anneröd, near Moss. Sp. gr., 8.893.
Q. From Elvestad. Sp. gr., 9.145.
R. From Elvestad. Sp. gr., 8.320.
S. From Skraatorp. Sp. gr., 8.966.
T. From Huggenaskilen. Sp. gr., 8.930.
U. Cleveite from Arendal. Sp. gr., 7.500.
V. From Arendal.

	P	Q	R	S	T	U	V
UO_3	30.63	25.36	22.04	32.00	35.54	41.71	26.80
UO_2	46.13	50.74	43.03	43.88	43.38	24.18	44.18
ZrO_2?	.06	.08	8.43	....	....	3.66	....
ThO_2	6.00	8.48		8.98	6.63		4.15
CeO_2	.18	.21		.17	.20		None.
$(La, Di)_2O_3$	.27	.26		.36	.23		.67
$(Y, Er)_2O_3$	1.11	1.10		.97	1.03	9.76	9.05
PbO	9.04	10.06	8.58	9.46	9.44	10.54	10.95
CaO	.37	.77	.37	.36	.41	1.06	.61
MgO	Traces.	Traces.	.13	Traces.	.13	.10	.04
Alkalies						.23	.15
H_2O	.74	.73	.74	.77	.79	1.23	Undet.
He, etc	.17	.18	.15	.15	.15	Undet.	.18
Fe_2O_3	.25	.21	.30	.09	.32	.03	.24
MnO	....	.06	....	....	....	....	....
SiO_2	.22	.38	.29	.53	.49	.90	.50
P_2O_5	.02	.04	Trace.	(?)	Trace.	....	Trace.
Insoluble	4.42	.45	15.45	1.54	.42	1.10	1.19
	99.61	99.11	99.51	99.26	99.16	94.50	98.71

XVII. CARBONACEOUS MINERALS.

QUISQUEITE.

A remarkable substance associated with the patronite of Minasragra, Peru. Analyzed and described by W. F. Hillebrand.

S, soluble in CS_2	15.44
S, combined	31.17
C	42.81
H	.91
N	.47
O, by difference	5.39
Moisture, at 105°	3.01
Ash[a]	.80
	100.00

[a] Highly vanadiferous.

INDEX.

○

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 592

MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN 1913

BY

ALFRED H. BROOKS AND OTHERS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1914

CONTENTS.

ILLUSTRATIONS.

MINERAL RESOURCES OF ALASKA, 1913.

By Alfred H. Brooks and others.

PREFACE.

By Alfred H. Brooks

The present volume is the tenth of a series of annual bulletins[1] treating of the progress of mining in Alaska and summarizing the results achieved during the year in the investigations of the mineral resources of the Territory. In preparing these reports the aim is prompt publication of the most important economic results of the year. The short time available for the preparation of the reports does not permit the complete office study of the notes and specimens; hence some of the statements made may be subject to modification when the researches have been completed. Those interested in any particular district are therefore urged to procure a copy of the complete report on that district as soon as it is available.

This volume, like those previously issued, contains both preliminary statements on investigations made during the year and summaries of the conditions of the mining industry, including statistics of mineral production. It is intended that this series of reports shall serve as convenient reference works on the mining industry for the years which they cover. Lack of funds prevents a visit to every mining district each year by a member of the Survey, and therefore the data used in preparing the summary on mining development are in part based on information gleaned from various reliable sources.

Again, as in previous years, the writer is under great obligations to many residents of the Territory for valuable data. Those who have thus aided him include many mine operators, engineers, prospectors, Federal officials, and officers of banks and of transportation and commercial companies. It is impossible to enumerate all who have contributed information, but special acknowledgment should be made to the Director of the Mint; Wells-Fargo Express Co.; the

---

[1] Report on progress of investigations of the mineral resources of Alaska, 1904 [to 1912]: U. S. Geol. Survey Bull. 259 [284, 314, 345, 379, 442, 480, 520, and 542, respectively].

Alaska Mexican Gold Mining Co., Alaska United Gold Mining Co., and Alaska Treadwell Gold Mining Co., of Treadwell; George M. Esterly, of Nizina; Stephen Birch, of Kennecott; Charles S. Matthison, of Hope; John L. Abrams, of Fortymile; J. J. Hillard, of Eagle; T. E. Phillip, of Jack Wade; W. J. Reynolds and A. J. Childs, of Deadwood; Frank A. Reynolds, of Circle; E. H. Boyer, R. C. Wood, F. Cook, A. Bruning, American Bank, and First National Bank, of Fairbanks; S. J. Marsh, of Caro; Charles Fornander and A. Cameron, of Ruby; William R. Lloyd, of Glacier; J. C. Felix, of Hughes; Cyril P. Wood, T. L. Thurston, and Charles Estmere, of Iditarod; W. A. Vinal, of Ophir; Harold Seddon and W. F. Green, of Tocotna; William Bailis, of Tuluksak; William Loiselle, of Quinhagak; E. R. Stivers, of St. Michael; J. W. J. Reed, of Nome; G. A. Adams, of Council; P. J. Coston, of Candle; and M. F. Moran, of Shungnak.

The arrangement and manner of treatment in this volume are the same as in those previously issued. First, papers of a general character are presented, followed by those treating of special districts, arranged geographically from south to north. This bulletin contains 21 papers by 11 authors. One of these papers deals with administrative matters, one treats of the mineral deposits of all Alaska, one is a general summary of the mining industry, and the remainder deal more specifically with the economic geology of certain districts. In the geologic papers emphasis is laid on the conclusions having immediate interest to the miner. These conclusions are discussed here briefly but will be more fully treated in reports now in preparation. The need of prompt publication requires that the illustrations in this volume be of the simplest kind.

ADMINISTRATIVE REPORT.

By Alfred H. Brooks.

INTRODUCTION.

The fact that the appropriation for the continuation of the investigation of the mineral resources of Alaska in 1913 was not made until June 23, 1913, much curtailed the field season of several of the parties and thereby greatly enhanced the cost of the work. Out of a total of 14 field parties only 5 had a full season's work. The loss in time, due to the delay in appropriation, amounted to an average of one month, or 29 per cent, for each of 8 field parties. A careful estimate, based on the allotments to these parties and the cost of the additional month of field work, shows that the actual monetary loss occasioned by the delay—that is, expenditure for which there was no return—was $7,120, or over 7 per cent of the total appropriation. There was also a loss of efficiency brought about by the delay of the field work and consequent change of plans which can not be expressed in figures. It can be stated, however, that the delay in appropriation for two successive years, the full appropriation for 1912–13 not being available until August 24, 1912, has put the Alaska field work nearly one year behind. This is indicated by the table showing progress of surveys (p. 9).

Fourteen parties in all were engaged in surveys and investigations during 1913. Of these, two started field work in May, three in June, seven in July, and two in August. The average length of the Alaska field season is 110 days; the average of all the parties in 1913 was 73 days. The 14 parties included 12 geologists, 1 geologic assistant, 4 topographic assistants, 2 hydraulic engineers, and 34 packers, cooks, and other assistants. Nine of these parties were engaged in geologic work, four in topographic surveys, and one in investigation of water resources. The results can be summarized as follows:

The areas covered by geologic exploratory surveys, on a scale of 1:500,000 (8 miles to the inch), amount to 3,500 square miles; by geologic reconnaissance surveys, scale 1:250,000 (about 4 miles to the inch), 2,950 square miles; by detailed geologic surveys, scale 1:62,500 (1 mile to the inch), 180 square miles. Much of the time of the geologists was devoted to special field problems, the results of which can not be expressed areally.

The areas covered by topographic exploratory surveys, on a scale of 1:500,000, amount to 3,400 square miles; by topographic reconnaissance surveys, 2,535 square miles; by detailed topographic surveys, 287 square miles.

Twenty-five stream-gaging stations were maintained for an average of 12 weeks each. The results served to indicate in some degree the possibilities for developing water power in the lower Copper River basin, along the eastern shore of Prince William Sound, and on Kenai Peninsula. This work also included excursions into the Bering River coal field and the Willow Creek district.

To state the work geographically, two parties worked in southeastern Alaska, one in the Yakataga region, one in the Chitina basin, one in the Prince William Sound, lower Copper, and Kenai Peninsula regions, one on Prince William Sound, two in the lower Susitna basin, two in the upper Susitna basin, two in the Matanuska basin, and one in the Yukon-Koyukuk region. The work of one party was divided between the Fairbanks district and Seward Peninsula.

Among the important results of the year are the completion of the reconnaissance of the marble deposits of southeastern Alaska, a reconnaissance survey of the Yakataga region, a detailed geologic and topographic survey of the Willow Creek district, a topographic and geologic reconnaissance survey of the Broad Pass region, in the upper Susitna basin, the completion of the general survey of the Matanuska coal field, and a geologic exploration of the little-known region lying between the lower Koyukuk River and the Yukon.

The following table shows the allotment, including both field and office expenses, of the total appropriation of $100,000 to the regions investigated. In preparing this table the general office expenses are apportioned to the several allotments, account being taken of variations in character of work. The results are expressed in round numbers. The "general investigations" include, among other things, the cost of collecting mineral statistics and of office work relating to the field investigations of previous seasons.

Approximate geographic distribution of Alaskan appropriation, 1913.

Southeastern Alaska	$7,000
Yakataga region	6,000
Copper River	10,500
Prince William Sound	7,000
Kenai Peninsula	1,500
Susitna basin	25,500
Matanuska basin	23,500
Yukon basin	8,500
General investigations	4,500
Unallotted	6,000
	100,000

In the following table the approximate amount of money devoted to each class of investigations and surveys is indicated. It is not possible to give the exact figures, as the same man may have carried on the different kinds of work, but this table will serve to elucidate ar table, which will summarize the complete areal surveys.

Approximate allotments to different kinds of surveys and investigations in Alaska, 1913.

Geologic and topographic exploration	$4,650
Geologic reconnaissance surveys	17,450
Detailed geologic surveys	5,350
Special geologic investigations	11,100
Reconnaissance topographic surveys	7,400
Detailed topographic surveys	20,700
Investigation of water resources	6,300
Collecting statistics of mineral production	1,250
Miscellaneous, including administration, inspection, clerical salaries, office supplies, and equipment	20,800
Unallotted	6,000
	100,000

Allotments for salaries and field expenses, Alaskan work, 1913.

Scientific and technical salaries	$38,800
Field expenses	38,930
Clerical and other office and miscellaneous expenses	16,270
Unallotted	6,000
	100,000

The following table exhibits the progress of investigations in Alaska and the annual appropriations since systematic surveys were begun in 1898. A varying amount is expended each year on special investigations yielding results which can not be expressed in terms of area.

Progress of surveys in Alaska, 1898–1913.

Year.	Appropriation.	Areas covered by geologic surveys.			Areas covered by topographic surveys.[a]					Investigations of water resources.	
		Exploratory (scale 1: 500,000, 1: 625,000, or 1 : 1,000,000).	Reconnaissance (scale 1 : 250,000).	Detailed (scale 1 : 62,500).	Exploratory (scale 1: 500,000, 1: 625,000, or 1 : 1,000,000).	Reconnaissance (scale 1: 250,000; 200-foot contours).	Detailed (scale 1: 62,500; 25, 50, or 100 foot contours).	Lines of levels.	Bench marks set.	Gaging stations maintained part of year.	Measurements of stream volume.
		Sq. m.	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Miles.*			
1898	$46,189	9,500	....	....	12,840	2,070	....	....	....	......	......
1899	25,000	6,000	....	....	8,690	....	....	....	....	......	......
1900	60,000	3,300	6,700	....	630	11,150	....	....	....	......	......
1901	60,000	6,200	5,800	....	10,200	5,450	....	....	....	......	......
1902	60,000	6,950	10,050	....	8,330	11,970	96	....	....	......	......
1903	60,000	5,000	8,000	96	....	15,000	....	....	....	......	......
1904	60,000	4,050	3,500	....	800	6,480	480	86	19	......	......
1905	80,000	4,000	4,100	536	....	4,880	787	202	28	......	......
1906	80,000	5,000	4,000	421	....	13,500	40	....	....	14	286
1907	80,000	2,600	1,400	442	....	6,120	501	95	16	48	457
1908	80,000	2,000	2,850	604	....	3,980	427	76	9	53	556
1909	90,000	6,100	5,500	450	6,190	5,170	444	....	....	81	703
1910	90,000	....	8,635	321	....	13,815	36	....	....	69	429
1911	100,000	8,000	10,550	496	....	14,460	246	....	....	68	309
1912	90,000	....	2,000	525	....	....	298	....	....	69	381
1913	100,000	3,500	2,950	180	3,400	2,535	287	....	....	24	185
	1,161,189	72,200	76,035	4,071	51,080	116,580	3,642	459	72	......	......
Percentage of total area of Alaska	....	12.31	12.97	0.69	8.71	19.88	0.62	....	....	......	......

---

[a] The Coast and Geodetic and International Boundary surveys have also made topographic surveys in Alaska. The areas covered by these surveys are, of course, not included in these totals.

GEOGRAPHIC DISTRIBUTION OF INVESTIGATIONS.

GENERAL WORK.

From January 1 to February 15, 1913, most of the time of the writer was devoted to the work of the Alaska Railroad Commission, of which he was vice chairman. During this time G. C. Martin had charge of the division. The writer was engaged in office work until June 30, when he proceeded to Alaska. A plan to visit the Willow Creek district could not be carried out in the time allotted, because of the nonoperation of the Alaska Northern Railroad. Several points on Cook Inlet were visited, and about 10 days were spent with B. L. Johnson in reviewing the geology of the Ellamar district and adjacent regions.

The writer attended the Thirteenth International Geological Congress at Toronto August 7 to 14 as official delegate and later made an excursion through the Canadian Cordillera, visiting a number of mining camps in British Columbia. He arrived in Washington on September 19.

Of the time devoted to office investigations during the year 1913 the writer devoted 33 days to the work of the Alaska Railroad Commission, 20 days to reading and revising manuscripts, 10 days to preparing matter for the annual progress report, 4 days to preparing the annual Alaska press bulletin, 7½ days to work on statistics of mineral production, 12 days to work of the advisory committee on a new Survey building, and 33 days to scientific work.

R. H. Sargent continued the general supervision of the topographic surveys and map compilation in addition to carrying on his own field work. E. M. Aten continued as office assistant and, during the absence of the geologist in charge and of the three senior geologists, acted as administrative head of the division. He also continued to assist in collecting statistics of production of precious metals in Alaska. Two clerks and one draftsman were employed throughout the year and one other clerk for about six months.

SOUTHEASTERN ALASKA.

Reconnaissance geologic surveys of all the mining districts of southeastern Alaska were completed in 1910, and detailed investigations of several of the more important mining districts have also been made. There still remains, however, much work to be done before the stratigraphic sequence, structure, and geologic history of this region can be established. It is only by the solving of the fundamental problems of geology that those of economic importance can be solved. For this reason further study of the geology of southeastern Alaska was undertaken in 1913.

In furtherance of this plan P. S. Smith began field work in the Ketchikan district on May 12 and continued until July 25, when he returned to Washington to take charge of the Alaska division during the writer's absence. Mr. Smith gained much new information, but further field studies must be made before there is justification for publishing the results.

In 1912 E. F. Burchard was temporarily transferred to the Alaskan division for the purpose of applying his special knowledge of the geology of building material to the marble deposits of southeastern Alaska. He completed the reconnaissance of most of the marble deposits of the Ketchikan and Wrangell districts in 1912.[1] In 1913 he extended this work northward into the Juneau and Sitka districts, thus completing the reconnaissance of the more important deposits of southeastern Alaska. A preliminary statement of the results achieved in 1913 is included in this bulletin and a more complete report is in preparation. In the course of the work Mr. Burchard discovered a large deposit of barite on Castle Island, in the Wrangell district. This deposit is described in a later section of this report.

YAKATAGA REGION.

Up to 1913 no geologist of the Survey had visited the Yakataga region, where placer gold had long been mined, petroleum seepages found, and coal deposits reported. The task of visiting this region, so difficult of access, was assigned to A. G. Maddren, who was assisted by E. O. Blades and one boatman. Landing at Katalla and following the beach with canoes and by packing, Mr. Maddren with two men reached Yakataga on July 13 and continued his field work until September 13. Mr. Blades, his assistant, did some work in this region until October 14. In the Yakataga district the party traveled chiefly on foot, carrying their supplies on their backs. In spite of this arduous work and the obstacles of heavy vegetation and glacial streams, they made reconnaissance surveys in places for some 15 miles inland. A fairly complete reconnaissance of the gold and oil bearing district was made and some of the coal beds were examined. The reconnaissance surveys covered an area of about 1,000 square miles. A preliminary statement of results is contained in this volume, and a more complete account is in preparation.

COPPER RIVER REGION.

In 1912 the preparation of a detailed base map of the copper-bearing area tributary to the Kuskulana was begun by D. C. Witherspoon, but was not completed, owing to the lateness of the appropriation. It fell to Mr. Witherspoon, assisted by S. A. Witherspoon with

---

[1] Burchard, E. F., Marble resources of Ketchikan and Wrangell districts: U. S. Geol. Survey Bull. 542, pp. 52-77, 1913.

a party of five men, to complete this survey in 1913. The map will be published on a scale of 1 mile to the inch, with 100-foot contours. In 1913 the survey of some 95 square miles was completed in spite of the fact that field work was not begun until July 18, but the work was continued, so far as weather permitted, until October 19. The geologic survey of this area is to be undertaken in 1914.

In connection with the work in the Susitna basin J. W. Bagley surveyed a belt adjacent to the Government wagon road extending from Beaver Dam to Gulkana. C. E. Giffin, while waiting at Valdez for the appropriation bill to be passed, made a similar survey along the wagon road from Beaver Dam to Valdez. The investigation of the water resources of the Copper River basin below Copper Center is described under the heading "Prince William Sound."

PRINCE WILLIAM SOUND.

In accordance with the plan of investigating the mineral resources of Prince William Sound, B. L. Johnson continued work in this field. His work, which began July 13, included a reexamination of some localities in the Ellamar district, which was done in cooperation with the writer. He also spent about two months in making a reconnaissance of the gold deposits of the Port Wells district and some further studies of the Port Valdez district and of Latouche Island. Field work was continued until October 27. A statement of results is contained in this bulletin.

C. E. Giffin utilized a part of the time while waiting at Valdez for the passage of the appropriation bill in making a hurried topographic reconnaissance from the head of Passage Canal to the Turnagain Arm watershed. This work was possible only through the courtesy of Col. Joseph P. O'Neil, commandant of Fort Liscum, who furnished Mr. Giffin with transportation from Valdez to Passage Canal and return. After the close of his field work in the Willow Creek district Mr. Giffin extended this survey through to Turnagain Arm (Pl. II).

INVESTIGATIONS OF WATER RESOURCES OF PRINCE WILLIAM SOUND, COPPER RIVER, AND KENAI PENINSULA.

In 1906 the Survey began the investigation of the water resources of the Nome district, and in 1907 similar investigations were begun in the Fairbanks district. During the succeeding six years stream gaging was done in most of the important placer districts of Seward Peninsula and of the Yukon-Tanana region. The results have been collated for each province and published.[1] Meanwhile, a preliminary study of water-power possibilities in southeastern Alaska was undertaken.[2]

---

[1] Henshaw, F. F., and Parker, G. L., Surface water supply of Seward Peninsula, Alaska: U. S. Geol. Survey Water-Supply Paper 314, 1913. Ellsworth, C. E., and Davenport, R. W., The surface water supply of the Yukon-Tanana region: U. S. Geol. Survey Water-Supply Paper 342 (in press).

[2] Hoyt, J. C., A water-power reconnaissance in southeastern Alaska: U. S. Geol. Survey Bull. 442, pp. 147-157, 1910.

These various investigations yielded a large number of facts of value to the mine operator and engineer. They cover, however, only a small part of the regions about the water resources of which a demand for information exists. The limits set by the funds available have prevented an expansion of this work. It seemed desirable, however, to make at least a preliminary study of the possibilities of developing water power in the Prince William Sound region and adjacent portions of the Copper River and Bering River basins, as well as in the Kenai Peninsula and Willow Creek districts. This task was undertaken in 1913 and assigned to C. E. Ellsworth and R. W. Davenport.

Work was begun on May 5 and Messrs. Ellsworth and Davenport studied the Prince William Sound region, lower Copper River basin, and the Bering River basin until August 12. They then proceeded to Seward and until September 4 devoted their time to the eastern section of Kenai Peninsula. Mr. Ellsworth then returned to Valdez and continued field work in the Prince William Sound and Copper River regions for the remainder of the season. Mr. Davenport continued investigation on Kenai Peninsula and also spent five days in the Willow Creek district. He returned to Valdez November 5 and took up work in that vicinity until the close of the season on November 25.

In the Bering River region only four days were spent in actual work, and six measurements of stream flow were made. The work in the Copper River basin was extended as far north as Copper Center and eastward on the Chitina as far as the Nizina placer district. Four gaging stations were maintained for an average of 17 weeks each. Forty-six measurements of stream flow were made and one rainfall station was established. Natural water-power sites are known to be widely distributed on streams entering Prince William Sound from the mainland and also from many islands, but because of lack of time the investigations were directed mainly to streams in the vicinity of Cordova, Ellamar, Valdez, and Port Wells, where mining and other activities are most important at the present time. In this region 10 gaging stations were maintained for an average of 12 weeks each, and 82 measurements of stream flow were made. In Kenai Peninsula and the Willow Creek district 10 gaging stations were maintained for an average of 10 weeks each and 51 measurements of stream flow were made.

The object of the reconnaissance was not only to gather data directly pertaining to the possibilities of developing water power in the area, but also to determine the need for such data and to gather information on which plans for a more detailed study could be based. Most of the work was hasty, and many streams of importance were not visited. The records of stream flow obtained cover only a short period during one season and should be supplemented by longer and more complete studies of the conditions before developments are undertaken. The information gathered during the last season is briefly set forth in this bulletin. A more complete report is now in preparation and will be published as a Survey water-supply paper.

WILLOW CREEK DISTRICT.

Geologic and topographic reconnaissance surveys of the Willow Creek district were made in 1906[1] and a brief examination of the auriferous lodes in 1910.[2] Since then the important lode-mining developments made in this field have led to a demand for more information, and therefore a detailed topographic and geologic survey was undertaken in 1913.

The base map was made by C. E. Giffin, who, with a party of three other men, began work on July 14 and completed the survey on August 27. In this time an area of 90 square miles was surveyed for publication on scale of 1 mile to the inch, with 100-foot contours. S. R. Capps, who mapped the geology of the same area on the same scale and made a detailed study of the ore deposits, began work on July 14 and closed on September 16. He had the assistance of a packer and a cook. A preliminary statement of results is contained in this bulletin, and the complete report is in preparation.

BROAD PASS REGION.

The Broad Pass region of the upper Susitna basin was explored by the Survey in 1898.[3] Further surveys in this field were planned for the summer of 1912, for which purpose provisions were sent in to Valdez Creek during the previous winter. The delay in the appropriation forced the abandonment of this plan, which was again taken up in 1913, when more supplies were shipped in. The topographic surveys of this field were made by J. W. Bagley, with a party of five, using phototopographic methods. Mr. Bagley began field work on July 9, after a long journey from the coast, and continued until August 23. Some 2,500 square miles was surveyed for publication, on a scale of 4 miles to the inch, with 200-foot contours. F. H. Moffit and J. E. Pogue made a geologic reconnaissance survey of a part of the same area. They began field work on June 29 and continued until August 28, covering an area of 800 square miles. A preliminary statement of results is contained in this volume, and a complete report is in preparation.

---

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, 1907.

[2] Katz, F. J., A reconnaissance of the Willow Creek gold region: U. S. Geol. Survey Bull. 480, pp. 139-152, 1911.

[3] Eldridge, G. H., A reconnaissance in the Sushitna basin and adjacent territory, Alaska: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 1-30, 1900.

MATANUSKA BASIN.

The detailed survey of the lower and more important part of the Matanuska coal field was completed in 1910,[1] but the upper part of the field was known only through the reconnaissance survey of 1906. The importance of the district justified the further investigation made in 1913.

R. H. Sargent made a base map of 102 square miles in this region for publication on a scale of 1 mile to the inch, with 50-foot contours. He was assisted by R. W. Chaney and five other men and began field work on July 22 and closed on September 26.

The geologic work was done by G. C. Martin, assisted by J. B. Mertie, jr., and R. M. Overbeck, together with three camp hands. This party began field work on July 14 and closed on October 9. It was originally planned that a detailed geologic survey of the entire coal field should be made, but as the party was a month late in the field, owing to delay in the appropriation, this plan proved impracticable. Therefore, only the areas of actual coal outcrops were studied in detail, and at the same time a reconnaissance was extended over a large area to establish the general distribution of the coal measures as well as of the other formations. The locality of the newly discovered placer deposits in this field was also examined. A concise statement of results is presented elsewhere in this volume, and a more complete report is in preparation.

YUKON-KOYUKUK REGION.

The region between the lower Koyukuk and Yukon rivers was up to 1913 but little known. To be sure, prospectors had roamed over it and reported the occurrence of some auriferous gravels, but the existing maps of the west end of this field were very inaccurate, and little placer mining had been going on for several years in the so-called Indian River or Red Mountain district. To meet these conditions H. M. Eakin, with a party of three men, carried a geologic and topographic exploration from a point near the mouth of Dall River southwestward to the Koyukuk, passing through the Indian River placer district. On his return Mr. Eakin traveled in a southerly direction, reaching the Yukon near the mouth of Melozi River. This survey was carried on from June 19 to August 20 and covered an area of about 2,400 square miles, for publication on a scale of 8 miles to the inch. The results are summarized in this volume and will be presented more at length in a report now in preparation. Mr. Eakin also spent about 10 days at the close of the season in a study of the gold placers of the Ruby district.

---

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley: U. S. Geol. Survey Bull. 500, 1912.

FAIRBANKS DISTRICT AND SEWARD PENINSULA.

The progress in lode mining at Fairbanks led to further studies of this field by Theodore Chapin, who arrived at Fairbanks on August 12 and continued his work until August 31. He then proceeded to Nome and made an investigation of the mining developments in Seward Peninsula. This work occupied him until October 8. His results are presented in other parts of this volume.

COLLECTION OF STATISTICS.

Since 1905 the writer has been charged with the duty of collecting the statistics of the production of precious metals in Alaska. Previous to that time only the total production of Alaska was known, the distribution by districts being only very general and in part entirely inaccurate. Since 1905 an attempt has been made to distribute the gold, silver, and copper production by districts. So far as the lode mines are concerned this distribution has been based on the returns of output reported by the individual producers, who are the only accurate sources of information. As a result accurate figures are now available for both the total lode production and the production by districts. Far different is the case with the gold-placer production. While many operators have shown their appreciation of the fact that accurate statistics are of first importance to the mining industry by promptly furnishing information on production, there is still a large percentage of the total number who make no returns. This neglect on their part greatly diminishes the accuracy of the figures of production published for certain districts. In fact, were it not for the public spirit shown by many residents of the Territory who supplement by estimates the partial statistics collected from producers it would not be possible even to approximate the output of many of the placer camps. The refusal of many operators to furnish statements of production is all the more surprising because it is in such strong contrast to the spirit of cooperation with the Survey they have shown in other matters and is also so different from the attitude of the placer-mine operators in the States, all of whom make returns. It is believed that this action by Alaskan placer miners is due largely to failure to appreciate the importance of accurate statistics. The conditions are, however, very discouraging to those who are trying to serve the mining industry of Alaska by attempting to procure accurate statistics of mineral production.

PUBLICATIONS.

During 1913 the Survey published ten bulletins and one water-supply paper relating to Alaska. One bulletin is in press. In addition the authors' work on one professional paper, two bulletins, and one water-supply paper has been completed, and three publications will soon be sent to press. Three other reports are in preparation. The compilation of a new general map of Alaska is under way. These publications are listed on page 17.

REPORTS ISSUED.

BULLETIN 502. The Eagle River region, southeastern Alaska, by Adolph Knopf; including detailed geologic and topographic maps. (Issued in March, 1913.)

BULLETIN 525. A geologic reconnaissance of the Fairbanks quadrangle, Alaska, by L. M. Prindle, with a detailed description of the Fairbanks district, by L. M. Prindle and F. J. Katz, and an account of lode mining near Fairbanks, by P. S. Smith; including reconnaissance and detailed geologic and topographic maps. (Issued in June, 1913.)

BULLETIN 526. Coastal glaciers of Prince William Sound and Kenai Peninsula, Alaska, by U. S. Grant and D. F. Higgins. (Issued in June, 1913.)

BULLETIN 532. The Koyukuk-Chandalar region, Alaska, by A. G. Maddren; including topographic and geologic reconnaissance maps. (Issued in June, 1913.)

BULLETIN 533. Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit; including detailed topographic and geologic reconnaissance maps. (Issued in August, 1913.)

BULLETIN 534. The Yentna district, Alaska, by S. R. Capps; including topographic and geologic reconnaissance maps. (Issued in June, 1913.)

BULLETIN 535. A geologic reconnaissance of a part of the Rampart quadrangle, Alaska, by H. M. Eakin; including geologic and topographic reconnaissance maps. (Issued in June, 1913.)

BULLETIN 536. The Noatak-Kobuk region, Alaska, by P. S. Smith; including topographic and geologic reconnaissance maps. (Issued in September, 1913.)

BULLETIN 538. Geologic reconnaissance of the Circle quadrangle, Alaska, by L. M. Prindle; including topographic and geologic reconnaissance maps. (Issued in December, 1913.)

WATER-SUPPLY PAPER 314. Surface water supply of Seward Peninsula, Alaska, by F. F. Henshaw and G. L. Parker, with a sketch of the geography and geology, by P. S. Smith and a description of methods of placer mining, by Alfred H. Brooks; including topographic reconnaissance maps. (Issued in May, 1913.)

REPORTS IN PRESS.

BULLETIN 576. Geology of the Hanagita-Bremner region, Alaska, by F. H. Moffit; including topographic and geologic reconnaissance maps.

REPORTS SUBMITTED FOR WHICH ILLUSTRATIONS ARE BEING PREPARED.

PROFESSIONAL PAPER 87. Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska, by C. W. Wright; including detailed geologic and topographic maps.

BULLETIN 578. The Iditarod-Ruby region, Alaska, by H. M. Eakin; including geologic and topographic reconnaissance maps.

BULLETIN 587. Contributions to the geology and mineral resources of the Kenai Peninsula, Alaska, by G. C. Martin, B. L. Johnson, and U. S. Grant; including geologic and topographic reconnaissance maps.

WATER-SUPPLY PAPER 342. Surface water supply of the Yukon-Tanana region, Alaska, by C. E. Ellsworth and R. W. Davenport; illustrated by topographic reconnaissance maps.

REPORTS IN PREPARATION.

Geology of the Glacier Bay and Lituya region, Alaska, by F. E. Wright and C. W. Wright; including geologic reconnaissance map.

Geology of the region along the international boundary from Porcupine River to the Arctic Ocean, by A. G. Maddren; including detailed geologic map.

Geology and mineral resources of the Ellamar district, Prince William Sound, Alaska, by S. R. Capps and B. L. Johnson.

THE MINERAL DEPOSITS OF ALASKA.

By Alfred H. Brooks.

INTRODUCTION.

The work of determining the areal distribution and mode of occurrence of Alaska's mineral deposits has been in progress for 16 years, and the results are recorded in many different publications. These are necessarily incomplete, for they relate to a territory almost continental in its dimensions.

In view of the present great interest in Alaska, it has seemed desirable to present a brief summary of what is known of the mineral deposits of the Territory. There is no intention of making a new contribution to economic geology, but solely of presenting a concise and somewhat popular treatment of the subject. As the geology of the metalliferous lodes has been presented at some length in a paper[1] recently published, this subject will receive only cursory treatment here.

The data to be presented are taken from the many Survey publications relating to the geology and mineral resources of Alaska, which are listed at the end of this volume. More special use has been made of the summary reports listed below. No further reference will be made in this paper to the Survey publications relating to Alaska from which data have been taken.

SUMMARY REPORTS ON GEOLOGY AND MINERAL RESOURCES OF ALASKA.

Note.—An asterisk (*) indicates that the Survey's stock of the publication is exhausted, but that it can be obtained of the Superintendent of Documents, Washington, D. C., at price indicated.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.

*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate by Cleveland Abbe, jr., and a topographic map and description thereof by R. U. Goode. Professional Paper 45, 1906, 327 pp. $1.

The mining industry in 1906, by A. H. Brooks. Bulletin 314, 1907, pp. 19–39.

Markets for Alaska coal, by G. C. Martin. Bulletin 284, 1906, pp. 18–29.

Outline of economic geology, by A. H. Brooks (in The gold placers of parts of Seward Peninsula). Bulletin 328, 1908, pp. 111-139.

---

[1] Brooks, A. H., Geologic features of Alaskan metalliferous lodes: U. S. Geol. Survey Bull. 480, pp. 43–93, 1911.

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358, 1908, 72 pp.

*The distribution of mineral resources in Alaska, by A. H. Brooks. Bulletin 345, 1908, pp. 18–29. 45c.

*The possible use of peat fuel in Alaska, by C. A. Davis. Bulletin 379, 1909, pp. 63–66. 50c.

Mineral resources of Alaska, by A. H. Brooks. Bulletin 394, 1909, pp. 172–207.

The preparation and use of peat as a fuel, by C. A. Davis. Bulletin 442, 1910, pp. 101–132.

Alaska coal and its utilization, by A. H. Brooks. Bulletin 442, 1910, pp. 47–100.

Geologic features of Alaskan metalliferous lodes, by A. H. Brooks. Bulletin 480, 1911, pp. 43–93.

*Railway routes from the Pacific seaboard to Fairbanks, by A. H. Brooks. Bulletin 520, 1912, pp. 45–88. 50c.

*Tin resources of Alaska, by F. L. Hess. Bulletin 520, 1912, pp. 89–92. 50c.

Marble resources of Ketchikan and Wrangell districts, by E. F. Burchard. Bulletin 542, 1913, pp. 52–77.

Surface water supply of Seward Peninsula, Alaska, by F. F. Henshaw and G. L. Parker; with sketch of geography and geology by P. S. Smith, and description of methods of placer mining by A. H. Brooks. Water-Supply Paper 314, 1913, 317 pp.

Surface water supply of the Yukon-Tanana region, Alaska, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 342 (in press).

A water-power reconnaissance in south-central Alaska, by C. E. Ellsworth and R. W. Davenport; with a report on water power in southeastern Alaska by J. C. Hoyt. Water-Supply Paper — (in preparation).

GEOGRAPHIC DISTRIBUTION.

MAP OF MINERAL RESOURCES.

The distribution of the mineral resources of Alaska, so far as known, is indicated on the accompanying map (Pl. I, in pocket). This map is based for the most part on the observations of members of the Geological Survey, but some data from other reliable sources have been used relating to localities not yet examined by the Survey geologists. The map is a revised edition of one published in 1912 as Plate I in Bulletin 520.

The distribution of the different kinds of mineral deposits is indicated by symbols, so far as the small scale of the map would permit, but it has not been possible everywhere to make these symbols altogether consistent. The symbol for gold placers marks the localities where placer gold has been found in commercial quantities, but for the most part it indicates only those places where actual mining has been done.[1] The symbol for auriferous lodes indicates chiefly the operating mines but includes some prospects which have not yet been productive. The symbol for copper marks the mine localities, as well as prospects. The symbol for tin deposits indicates both placer and lode deposits, though the latter are for the most part only prospects.

---

[1] For statistics of mineral production see pp. 46, 47, 52–5, 72.

The fact that the geology of coal is in general much simpler than that of the metalliferous deposits makes it possible to present more facts in regard to its distribution and these with a far greater degree of confidence. On the map the occurrence of sediments belonging to the horizons of the coal-bearing rocks is indicated by stippling, but no attempt is made to distinguish between the coal measures of different geologic ages. The areas shown can be regarded as the most promising fields for coal prospecting, but should not be taken to indicate the actual distribution of workable coal seams. The areas known to carry coal, probably in workable beds, are marked in black with a letter indicating the quality of the coal, and at several of the localities thus marked there has been a little coal mining. The location of petroleum seepages is also indicated on the map. All but one of the known seepages occur on the Pacific coast, the exception being on the north Arctic coast. The symbols for petroleum seepage in the Katalla field, near Controller Bay, also mark the position of several wells from which there has been a small production.

Some marble quarrying has been done in southeastern Alaska, and the known deposits of commercially valuable marble in this field are shown on the map. There are beds of marble in other parts of Alaska, but they have not been sufficiently studied to indicate that they have value.

Besides the production from mineral deposits indicated on the map there has been a small output from garnet, graphite, and jade deposits. A large amount of silver and a little lead have been recovered from ores mined chiefly for other metals. Cinnabar, molybdenite, stibnite, wolframite, scheelite, barite, and other minerals have also been found. Iron ores occur at a number of localities but are undeveloped. Asbestos and mica in workable deposits have been reported. Some sulphur has been found in association with active volcanoes. Granite is very abundant in most parts of the Territory, and some of it is probably suitable for building stone. Limestone and shale suitable for the manufacture of cement have been found at several localities but have not been utilized. Peat is widely distributed. Hot springs are abundant and several have been used for local sanitariums. A little mineral water has been utilized.

MINING DISTRICTS.

Southeastern Alaska.—In southeastern Alaska are the Juneau gold belt, the Porcupine gold-placer district, and the Ketchikan copper district, which contains some auriferous veins. Some iron ore has been found in association with copper in the Ketchikan district and also as distinct ore bodies near Haines. Silver-bearing galena lodes have been found in the Ketchikan and Wrangell districts. Gold lodes occur in Sitka district, where there is also one gypsum mine.

Marble is widely distributed in southeastern Alaska and has been quarried in the Wrangell and Ketchikan districts. Garnets have been mined in the Wrangell district, where a deposit of barite has also been found. There are some small areas of lignite-bearing rock on Admiralty and Kupreanof Islands. Granite is widely distributed in southeastern Alaska. This province contains several hot springs.

Central Pacific coast region.—The name central Pacific coast region is here used to designate the mountain and foothill belt stretching eastward from Copper River to Lituya Bay. In it lies the Bering River coal field, with its high-grade coals. Coal, probably of a bituminous character, has been found in the foothills north of Yakataga, near the head of Yakutat Bay, and is reported on the southwest slope of Mount St. Elias. The Katalla petroleum field, near Controller Bay, lies in this region, and oil seepages have also been found 60 miles to the east at Yakataga. Gold beach placers have been worked at Yakataga and on Lituya and Yakutat bays.

Copper River basin.—The Copper River basin is known chiefly for the copper-bearing lodes of the Kotsina-Chitina district, now being developed, though some gold ores have also been found in its lower portions. The gold-placer districts of Nizina, Chistochina, and Bremner rivers are likewise within the Copper River basin.

Prince William Sound.—Gold and copper-bearing lodes are widely distributed in the Prince William Sound region and have been mined on a productive scale at several places. Some antimony and iron ores have also been found. Granite is rather widely distributed.

Kenai Peninsula.—In the eastern part of Kenai Peninsula there are gold placers, gold lodes, and a few copper-bearing lodes. Chromic iron and antimony lodes have also been found. The western half of the peninsula is underlain by lignitic coal measures, which occur also near Tyonek on the west side of Cook Inlet.

Matanuska and Susitna basins.—The Matanuska Valley is chiefly known for its high-grade coals, which occur in the upper part. In the southwestern part of the valley there are some lower-grade coals. A little placer gold has been found in northerly tributaries of the upper Matanuska, and at one locality some copper ore.

The Willow Creek district, named from a tributary of the lower Susitna, first developed in a small way for placer gold, is now a lode district. Some copper lodes have been found in the lower Talkeetna basin. The gravel of the Susitna Basin carries a little fine gold, but workable placers have as yet been found only in the Yentna district, on Willow Creek, and in the Valdez Creek district, lying in the headwater region. Lignitic coal-bearing rocks are widely distributed in the Susitna Basin.

Iliamna region.—There are some petroleum seepages on the west shore of Cook Inlet, north of Iliamna Bay. Gold and copper bearing lodes have been found in the region tributary to Iliamna and Clark lakes and to Kamishak Bay, and a little placer gold has been mined on a tributary of Clark Lake and in the headwaters of Mulchatna River.

Southwestern Alaska.—For the purpose of this description southwestern Alaska includes the Alaska Peninsula and adjacent islands, with Kodiak Island and the Aleutian chain. A little beach-placer gold has been mined on Kodiak and Popof islands. Some auriferous lodes and a few small areas of lignitic coal have been found on Kodiak Island. The mineral resources of the Alaska Peninsula include the bituminous coals of the Chignik and Herendeen fields, and some deposits of lignitic coal at other localities. Near Cold Bay there are some petroleum seepages. On Unga Island some gold and silver bearing lodes have been developed. A few copper-bearing lodes have also been found on the lower half of the Alaska Peninsula. A few small auriferous quartz veins have been found on Unalaska Island, in the eastern half of the Aleutian chain. Copper ores have been reported from these islands, and some sulphur deposits are said to occur near the vents of some of the active volcanoes. There is a considerable deposit of tuff, a volcanic ash—the recent ejecta of Mount Katmai volcano—that has been utilized as an abrasive.

Eastern shore of Bering Sea.—The eastern shore of Bering Sea from Bristol Bay to Norton Sound is, so far as known, without important mineral resources. A little placer gold has been found on tributaries of Goodnews Bay, a reentrant of the coast at the entrance to Kuskokwim Bay. Placer gold has also been mined on Bonanza Creek, a tributary of Ungalik River, which flows into Norton Sound. Some beds of lignitic coal have been found on Nunivak and Nelson islands and near the mouth of Unalaklik River, tributary to Norton Sound.

Kuskokwim basin.—The known mineral resources of the Kuskokwim basin include widely distributed gold placers, a few gold-bearing lodes, and some beds of lignitic coal. There appears to be a more or less broken belt of gold-bearing rocks which stretches northeastward from Goodnews Bay parallel to the lower course of the Kuskokwim, toward the Iditarod district, and a number of the streams traversing this belt carry auriferous gravels. Some placer gold has also been found in the Tocotna basin and on other westerly tributaries of the Kuskokwim. Cinnabar deposits also occur in this district. Some auriferous quartz lodes have been found in these several placer districts. Lignitic coal has been found on Big River, a southerly tributary of the South Fork of the Kuskokwim. Some coal of better grade has also been found near Iditarod. (See pp. 72–73.)

Yukon basin.—The gold deposits of the Yukon-Tanana region are the most valuable mineral resources in the Yukon basin. This region comprises the area bounded by the Yukon and Tanana valleys and the international boundary. Auriferous gravels are widely distributed in the region, which includes the important placer districts of Fairbanks, Hot Springs, Birch Creek, and Fortymile, besides a number of lesser note. In most of these districts some auriferous lodes have been found, and those of Fairbanks, at least, have proved to be of commercial value. Some deposits of stibnite and argentiferous galena are known in the Yukon-Tanana region. In the Hot Springs district some tin deposits have also been found. Auriferous mineralization is known south of the Tanana, where the placer districts of Bonnifield and Kantishna are situated. North of the Yukon are the Koyukuk, Indian River, and Chandalar placer districts. In the Koyukuk district some argentiferous lodes have been found, and in the Chandalar district several auriferous lodes have been developed. The Ruby gold placer district lies south of and tributary to the middle Yukon River. Some placer tin has been found in the Ruby district. To the southwest of this are the Innoko and Iditarod districts, where placer gold has been mined and lode gold found. Copper and gold lodes have been found in the headwater region of Tanana and White rivers, both tributaries of the Yukon. The Chisana placer district is also in the headwater region of the Tanana.

Lignitic coal is known in many places in the Yukon basin. The Nenana, the largest of the lignitic coal fields, lies on the south side of the Tanana Valley. There is another considerable area of rocks bearing lignitic coal on the south side of the Yukon between Seventymile River and Woodchopper Creek. Some beds of subbituminous coal occur on the north side of the lower Yukon, between Nulato and the mouth of the Innoko and have been mined in a small way. Hot springs are widely distributed in the Yukon basin.

Seward Peninsula.—The principal resources of Seward Peninsula, are the gold placers of the Nome and other districts. Some gold and silver bearing lodes have been exploited in a small way on the peninsula. A little graphite and garnet has been mined, and mica deposits are reported. Antimony-bearing veins have been developed, and some carrying a little copper are also known. Tin lode and placer deposits have been mined. Some scheelite has been recovered incidental to the mining of placer gold, and bismuth deposits have been found. Iron ore is reported. At Chicago Creek, in the northeastern part of the peninsula, lignitic coal has been mined. A little lignitic coal has also been found in other parts of the peninsula. Several hot springs are known in Seward Peninsula.

Kobuk-Noatak region.—A little placer gold has been mined on a tributary of Squirrel River and near Shungnak, both in the Kobuk basin, and auriferous gravels have been found at several localities in the Kobuk-Noatak region. Lodes carrying copper, gold, and silver have also been found in this region. A little lignitic coal is known in Kobuk basin. Jade has been obtained from this region. One hot spring has been found in the upper Kobuk and one in the upper Selawik valley.

Northern Alaska.—The region here designated northern Alaska includes the area drained by the rivers flowing into the Arctic Ocean north of Kotzebue Sound. No metalliferous deposits are known in this region, but coal is widely distributed. Near Cape Lisburne there are some high-grade bituminous coals, and 40 miles to the east is the Corwin field, containing extensive deposits of subbituminous coal. Coal is also known to occur at Wainwright Inlet and near the mouth of Anaktuvuk River. A petroleum seepage has been found southeast of Point Barrow, near the head of Smith Bay.

GEOLOGIC OCCURRENCE.

GOLD.

Geologic association.—As the placer gold was derived from a bedrock source, its occurrence as well as that of the auriferous lodes is an indication of the distribution of mineralization. (See map, Pl. I, in pocket.) Although all the factors which govern the accumulation of Alaska gold deposits are by no means fully understood, certain facts have been fairly well established. A large part of the auriferous mineralization is in regions which have been intruded by igneous rocks, such as granite or diorite. Many of the gold deposits occur near the contacts of intrusive rocks. These occurrences may be either in the intruded sediments or in the igneous rocks themselves, but their universal association with intrusives in many important districts and their absence where the intrusives are lacking can not be entirely fortuitous. This fact has led to the belief that the metal-bearing solutions which formed the gold deposits probably emanated from the same deep-seated source as the igneous rocks themselves. The mineralization is regarded in general as an after-effect of the igneous activity. This relation of mineralization to igneous rocks is especially noticeable in southeastern Alaska, but it also holds true in the Willow Creek, Fairbanks, Hot Springs, Chandalar, Innoko, Iditarod, and other districts. In general it is probably the law for the occurrence of gold in the entire Yukon and Kuskokwim basins. On Seward Peninsula no such relation between granitic rocks and gold deposits has been established. Here the mineralization along granite contacts is in some localities that of tin and associated ores; in others, galena.

In the Port Wells district of Prince William Sound there is evidence of a definite association of the auriferous mineralization and intrusive granites. Elsewhere on the sound this association is not so evident. At Valdez there are some intrusive dikes, but a genetic relation of these dikes with the gold-bearing quartz veins has not been established. The auriferous lodes of Kenai Peninsula are more or less closely associated with intrusive rocks, and the same is true in the Nizina and Chistochina districts.

The igneous rocks with which the genesis of most of the gold-bearing quartz veins appears to be connected are of the same general type and appear to belong to about the same epoch of intrusion—that of Jurassic and Lower Cretaceous time. The mineralization, which generally followed closely on the intrusion, is of the same general period as in the Cordilleran region of western North America. In view of this fact it becomes important to consider the general distribution of the granitic intrusives believed to belong to this epoch, for so far auriferous mineralization has been found associated only with these Mesozoic intrusives and by no means with all of them. Although both post-Mesozoic and pre-Mesozoic granites and diorites occur in Alaska, they are believed to be without any important mineralizing influence.

The Coast Range granodiorite of southeastern Alaska is the largest of the Mesozoic intrusive bodies and mineralization has been found on both sides of the extended intrusive belt which it forms. There are also many areas of granitic and allied intrusive rocks in the islands of southeastern Alaska and what is known of the geology of the St. Elias Range indicates the presence of similar intrusives there. The Yakataga placers are a further indication of auriferous mineralization in this area. The Talkeetna Mountains, lying north of the Matanuska Valley, are made up largely of granitic and chloritic rocks, probably for the most part intruded during Mesozoic times. The Willow Creek lode district is evidence of the presence of gold along the southwestern margin of this granitic area. Furthermore, several of the streams flowing into the Matanuska and crossing the granitic contact carry a little placer gold. There are many areas of intrusive granite in the Alaska Range, most of the higher peaks, including Mount McKinley, being granite stocks. The granite contacts in this area have been little studied, but some auriferous mineralization has been found along at least one of them. In the Iliamna region, again, there are abundant granitic intrusives and some mineralization. The Aleutian Islands are but little known. On Unimak, in the eastern part of the chain, a granite intrusive is known, and although the gold-quartz veins found here are of no economic value, they indicate mineralization and a possible site of other discoveries.

Granite is widely distributed in the Yukon-Tanana region, and its probable genetic relation to the gold deposits of Fairbanks and other districts has already been mentioned. The same relation appears to exist in the Chandalar, Koyukuk, Innoko, and Iditarod districts. There are abundant granitic intrusive rocks in the region lying between the lower Koyukuk and the Yukon, and here also a little placer gold has been found, giving evidence of mineralization. As already explained, in Seward Peninsula the mineralization definitely associated with granites is not that of gold; hence it may be that the auriferous deposits of this part of Alaska have a different origin from that of the deposits above described.

Types of deposits.—Alaska gold deposits fall into two general groups, lodes and placers. In the lodes the metal occurs in the hard rocks as the contents of veins or mineralized zones, usually in association with other metalliferous minerals. The gold placer is a body of unconsolidated material made up of gravel, sand, or clay containing a sufficient quantity of gold to permit profitable exploitation. This gold is more or less disseminated, but is usually found chiefly in the bottom layer of the deposit and at some places penetrates for considerable distances into the surface of the loose material of the bedrock floor. The placer gold is derived from the disintegration and erosion of auriferous lode deposits in the hard bedrock. The presence of rich placer deposits in a district is a hopeful indication that auriferous lodes occur, yet this does not necessarily follow, for the gold of the bedrock source may be too much disseminated to permit profitable exploitation.

Lodes.—The auriferous lodes of Alaska include many different types. The economically important ones can, however, for the most part be classed in two groups, the fissure veins and the disseminated lodes. There is also another type of minor importance—replacement deposits, in which the ore occurs along channels of solution, chiefly in limestones. In the vein deposits the ore body consists usually of quartz in which iron sulphides and other metalliferous minerals are more or less irregularly distributed. In these the ore body usually follows a more or less well-defined fissure in the country rock. This type is found at Sitka, at Port Valdez, on Kenai Peninsula, on Willow Creek, at Fairbanks, and elsewhere.

The disseminated deposits include those in which the gold and other minerals occur in a zone of fracturing. In deposits of this type the gangue material usually includes a large amount of the country rock, which in itself may be sufficiently mineralized to constitute an ore. Some of the disseminated deposits are zones of fracture, which are permeated by innumerable small quartz veins that carry the metal. These are properly stockwork deposits. Other disseminated deposits follow well-defined zones of movement or shearing bounded by fractures. In still others the walls are ill defined, there being a gradual transition from the lode to the unmineralized country rock; or a mass of igneous rock, such as a dike, may be fractured and then permeated by the mineral-bearing solutions, and the dike thus changed more or less completely into an ore body. As a general rule the disseminated deposits carry less gold than the fissure veins, and can be profitably mined only if they are of large dimensions and so located as to assure cheap exploitation.

The low-grade ores of the Juneau district, including those of the Treadwell mines, are the best examples in Alaska of the disseminated type of deposit. Similar deposits have been found elsewhere in Alaska, but have received little attention because of their unfavorable location. There are also certain ore bodies—in the Juneau district, for example—which are intermediate in type between the disseminated deposits and the fissure veins. This is to be expected, as the metallization is of the same character in both types.

In the Ketchikan district and probably elsewhere in Alaska there are a few gold deposits occurring in limestone. In these the ore bodies occupy channels of solution rather than of fracture, and they can be designated replacement deposits. So far this type of gold deposit in Alaska has been of little commercial importance.

It is not proposed to consider here in detail the mineral character of the gold lodes, which differ more or less in the different districts. In general, however, it may be said that the gold occurs free or in combination with various sulphides. Pyrite is present in nearly all the Alaska gold deposits and other sulphides are common. Many deposits carry some galena and in some it is present in considerable quantities. Tellurides have not been found in commercial quantities in any of the Alaska mining districts. Quartz is the dominating gangue mineral, with some calcite and in certain localities albite feldspar.

Placers.[1]— The formation of placers is determined by (1) the occurrence of gold in bedrock to which erosion has access; (2) the separation of the gold from the bedrock by weathering or abrasion; (3) the transportation, sorting, and deposition of the auriferous material derived by erosion.

It is self-evident that unless there is gold in bedrock, a subject already discussed, placers can not be formed. In most of the rich placer districts there was more or less concentration of auriferous material by weathering before it was sorted and transported by running water. There are, indeed, some gold placers where the concentration is due almost entirely to this weathering process. These are what are called "residual

---

[1] The genesis of gold placers has been discussed by the writer in The gold placers of parts of Seward Peninsula, Alaska: U. S. Geol. Survey Bull. 328, pp. 111-139, 1908.

placers," of which a few examples have been found in Alaska. The principal agency in the formation of placers is that of sorting and transportation by running water. This action can take place many times—that is, a placer may be formed by water transportation and then destroyed again by new stream cutting, when uplift or increased precipitation has revived the forces of erosion.

A classification of the placers can be made, first, on genesis; second, on form. The primary grouping, according to origin, would be "residual placers," "sorted placers," and "re-sorted placers." The residual placers are those in which there has been little or no water transportation of the gold, the concentration being due primarily to rock weathering, settling, and removal of soluble rock constituent with more or less movement on the hill slopes. The gold of the sorted placers is the result of transportation, sorting, and deposition by water, though in Australia some examples of sorting of gold-bearing material by wind action have been noted. The re-sorted placers are those in which the gold has passed through two or more periods of erosion before its final deposition. The residual placers are practically all of one type. The sorted and re-sorted placers embrace many subordinate types, named according to the form of occurrence.

It will be evident that the sorting and re-sorting of the auriferous gravel may have taken place either under present conditions of erosion and deposition or in an earlier period, when conditions may have been different. It is therefore desirable to distinguish between modern and ancient placers. The modern placers include the deposits of the present period of erosion, the ancient placers those of an older period of erosion having different physical conditions. For example, there is some evidence that the deep gravels of Fairbanks were laid down when the climate was warmer and the precipitation greater than now. Again, the high bench and elevated beach placers at Nome were deposited when the land stood lower relative to the sea than at present and the drainage channels were different. There are some still older gravels in Alaska, deposited in Tertiary time, which are auriferous, and if any of these are found to be locally rich enough to permit mining they will constitute another group of ancient placers.

The foregoing remarks will make it clear that each of the larger genetic groups of placers can be subdivided into modern and ancient according to whether they were formed under present conditions or those of the past. The Alaska residual placers are, however, so far as [illegible] all modern, though there is no inherent reason why ancient placers should not be found. The following summary presents [illegible]nt features of the above classification and while it is not altogether [illegible] consistent it will serve for the present discussion.

Classification of Alaska placers.

1. Residual placers.
2. Sorted placers:
    - Modern:
        - Hillside.
        - Creek.
        - River bar.
    - Ancient:
        - Gravel plain.
        - Bench of present streams.
        - Bench of former drainage system.
        - Deep gravel.
3. Re-sorted placers:
    - Modern:
        - Creek.
        - Beach.
    - Ancient:
        - Elevated beach.
        - Deep gravel.

It is evident that this, like most other classifications, contains intermediate types which may belong to either of two groups. Hillside placers, for example, are those that occur on hill slopes and do not occupy any well-defined channels. These, though usually water sorted to a certain extent, grade directly into deposits of a purely residual origin on the one hand and into stream or gulch deposits on the other. Again, a creek or gulch placer may be in part a sorted, in part a re-sorted deposit. Moreover, many of the ancient placers afford no evidence as to whether their gold gravels may not be re-sorted.

Residual placers have been found at a number of localities in Alaska, but have not constituted an important source of placer gold. For example, the hill slope where the Treadwell lode outcrops was formerly covered with the débris of weathering, and this material carried considerable gold. The recovery of this placer gold was one of the first of the mining activities in the Juneau district. A residual placer occurs near the divide between Anvil and Dexter creeks, near Nome. Examples of this type of deposit have also been found on Hill Creek, in the Fairbanks district, and on Happy Gulch, in the Iditarod district.

Sorted placers, or those which are the result of water transportation and deposition during one period of erosion, are the prevalent type of deposit throughout Alaska. To these belong not only those of the present watercourses, but also some of those deposited at an earlier time. These earlier deposits are in part preserved as bench deposits and in part deeply buried by more recent alluvium. The gold-bearing glacial débris is another type of auriferous alluvium, but the known Alaska deposits of this kind can not be classed as placers, because the gold is too finely disseminated to yield commercial deposits. It is important only in that it has furnished the gold for some of the re-sorted placers.

The hillside placers are occurrences of gold-bearing gravels on valley slopes not occupying well-defined channels but somewhat sorted by water and therefore not strictly residual placers. They form a transitional type between the residual and gulch placers. The placers of the present watercourses, termed creek or gulch placers, may be said to be now in process of formation. This process of erosion and deposition is so slow, however, that the present generation can not be expected to profit by it.

The present stream placers are chiefly deposits not more than 6 to 10 feet deep. They are not everywhere distinguishable from the deeper placers, which, though contained in present streams, have for the most part been laid down under physical conditions different from those which now exist. To cite localities of the occurrence of modern stream placers would be to list most of the placer districts of Alaska.

River-bar placers are those occurring in the larger streams having low gradients. In these the fine gold is deposited at certain places of minimum water movement. Some of these bar placers have locally been found rich enough to permit profitable exploitation by hand labor, but as a rule they are not extensive enough to warrant the installation of dredges. The gold in them seems to be concentrated on the surface and to be very much disseminated or absent in the rest of the deposit. The earliest mining in the Yukon was done on river bars during the low-water season. River-bar placers have also been mined on Birch Creek, on Fortymile and Koyukuk rivers, and on some of the streams of Seward Peninsula. As a whole, the river-bar placers have not been an important source of gold.

The gravel-plain placers occur chiefly in ancient and more or less elevated flood plains and deltas. These are in part modern but chiefly ancient placers and are somewhat intermediate in type between the creek and river placers. Some of the so-called tundra placers of Nome belong to this type. Their present importance has been derived chiefly from the fact that they furnished gold to some of the resorted beach and stream placers.

The commonest types of sorted ancient placers are those in the benches or terraces of present streams. These placers have all the characteristics of the modern stream placers, differing only in the fact that they have been dissected, as a rule because of uplift. Bench placers of this type are known in many of the mining camps of Alaska. A few placers of this type occur at Fairbanks, but these have been buried by later alluvium. One of the best examples of bench deposits is that on the north side of Glacier Creek, near Nome. Such placers are also found in Kenai Peninsula and in the Fortymile, Koyukuk, Innoko, Iditarod, and various other districts.

The high bench placers are those which resulted from stream action of a former drainage system, now preserved only in fragmentary form. Unlike the bench deposits of present valleys, they have no direct relation to the existing drainage channels. Such placers are not abundant in Alaska. The famous White Channel gravel of the Klondike contains placers of this type, but nothing like this has been found in Alaska. High gravels carrying some gold are known in the Minook Creek basin near Rampart and in the Ruby district of the middle Yukon, but no workable placers have been found in them. On the other hand, some high bench placers near Nome, forming the divide between Dexter and Anvil creeks, have been worked. This period of gravel deposition has not been recognized in other parts of Seward Peninsula.

Some of the richest Alaska placers are those occurring in deeply buried channels, forming the type here designated "deep gravels." The best-known examples of these deposits are found in the Fairbanks district. The Fairbanks deep gravels are the deposits of ancient watercourses which occupied the present valleys but are now buried under an accumulation of 20 to 300 feet of alluvium. Mining operations have shown that the deep gravels have a rather straight course with only a few large bends, and that they lie on a bedrock floor whose downstream slope is a little steeper than that of the present valley bottoms. Most of these channels are centrally located with reference to the bedrock slope of the valley. In this they are in strong contrast to the present streams, which, as a rule, occupy strikingly asymmetric valleys, one wall of which they follow closely. The gravels of these deep channels are in general from 10 to 40 feet in thickness, though the local maximum is much greater. They are covered by 10 to 200 feet of what is generally termed "muck." This is black humus and gray fine sand and silt and clay. Some of this material is talus derived from the valley slopes, and some is probably the deposit of sluggish streams. In the headwater regions of the creeks the deep gravels merge with those of the present streams, and here the entire section consists of gravels. It seems pretty certain that the deep-gravel placers of the Fairbanks district were formed under climatic conditions different from those which now exist. Evidence that will not be presented here makes it probable that when these deposits were formed the climate was warmer and the precipitation greater. Deep-gravel placers are also found in the Hot Springs and Rampart districts, and to this class probably belong some of the placers of other districts of the Yukon-Tanana region. Similar deposits have also been found in the Koyukuk district, and there are some deposits in Seward Peninsula which belong in this category.

Creek and gulch auriferous deposits that have derived their gold from the destruction of older placers, and therefore belong to the class of re-sorted placers, have been found in many of the Alaska districts. One of the best-known examples of the re-sorting process is the enrichment of the placers of Little Minook Creek, in the Rampart district, by the dissection of the high gravels. Re-sorted creek placers of this type have been found in the Hot Springs, Innoko, and Bonnifield districts and on Seward Peninsula.

The beach placers of Alaska are practically all of the re-sorted type. These are formed by the surf destroying alluvial deposits and concentrating their gold contents. The best-known examples of this class are the Nome beach placers, from which several million dollars' worth of gold has been won. Beach placers also occur along the Pacific seaboard near Lituya, at Yakataga, in the southern part of Kodiak Island, and on Popof Island. Some of these beach placers are annually more or less enriched by surf action. These are usually of small extent and can, therefore, be profitably exploited only by hand labor.

The ancient re-sorted placers probably include the same types as the modern ones. At Nome, for example, there are both buried and elevated beach placers formed at a time when the land stood at a different altitude relative to the sea. Not enough is known of the deep-gravel placers to permit a definite assignment of any of them to the re-sorted type. The great richness of some of them, combined with the irregular distribution of the gold, as in the Koyukuk region, suggests that some of these are re-sorted.

The mineral content of the placers needs no detailed description here. It varies according to the character of the bedrock from which the material has been derived. Besides the gold, other heavy minerals are present in the concentrates. Garnet, magnetite, pyrite, scheelite, wolframite, and sometimes ilmenite are found with placers. In the Nizina district native copper is abundant. In the York region the placer tin deposits were first worked for gold. Alluvial tin is also found in some of the Hot Springs gold placers. Cinnabar has been found in several of the Alaska gold placers. Some of the placers carry native silver, and a few minute grains of platinum have been found in some of the concentrates from the Yukon basin. Placer gold always carries some impurity, in which silver is the most abundant constituent.

COPPER.

Though there are some copper placers in Alaska, most of the valuable occurrences of this metal are in lodes. The copper-bearing lodes have much greater variety of occurrence than the auriferous lodes.

In the absence of definite knowledge regarding the genesis of some of these deposits an entirely consistent classification is not now possible. For the purpose of this writing, however, five types of copper deposits will be recognized, as follows:

1. Contact deposits carrying copper sulphides.
2. Disseminated copper sulphides in intrusive rocks.
3. Veins and fracture zones carrying copper sulphides associated with argillites and ancient volcanic rocks and occurring chiefly in regions of intrusive rocks.
4. Veins and fracture zones carrying copper sulphides cutting limestones and ancient volcanic rocks.
5. Native copper deposits in amygdaloidal lavas.

The contact deposits are closely connected with granitic and dioritic intrusive rocks and are believed to belong to the same epoch of mineralization as the gold lodes above described. The best-known copper lodes having this association are found in altered and recrystallized limestones at the contact with the intrusive rocks. Such occurrences have been found in the Ketchikan, Iliamna, Nabesna, and other districts. The ore bodies, which are of irregular outline and distribution, consist generally of chalcopyrite and pyrite (in places with bornite) in a gangue of garnet, magnetite, epidote, calcite, and quartz.

Disseminated sulphide deposits occur in the intrusive rocks of Kasaan Peninsula. This forms the second type of copper deposit, which as yet is unimportant commercially, but one commercial ore body having been developed at the head of Kasaan Bay. Here bornite is scattered through a heavy green dioritic rock containing much biotite. There is some chalcocite and chalcopyrite in this deposit.

The third type of deposit is that in veins and shear zones cutting slates and ancient volcanic rocks. These have been found chiefly in regions of Mesozoic intrusives and are probably genetically related to these igneous rocks, but they do not lie in the zones of contact metamorphism. Some of them are fissure veins which cut country rock of various kinds, but chiefly ancient volcanic rocks and slates. These differ little from the gold-bearing veins except in their mineral content. Examples of this type have been found in the Ketchikan district and elsewhere in Alaska.

Another variety of this type comprises the mineralized zones of fracture, also in country rock of slates and greenstones. In these the copper may be disseminated but is more commonly in part concentrated in lenses that furnish the workable ore shoots. These ores are in part deposited in open spaces, in part replacements of country rock. Such deposits are found in Ketchikan district but are better known by their occurrence in deposits of the Ellamar district, on Prince William Sound. The Ketchikan deposits of this type are more or less definitely associated with Mesozoic intrusive rocks. Such a relation to igneous rocks, though suspected, has not been established for the Prince William Sound region. The ores of this type are chiefly chalcopyrite and pyrrhotite, with which are associated pyrite. sphalerite, arsenopyrite, galena, gold, and silver.

The fourth type includes the copper deposits occurring in fissure veins and shear zones, cutting limestone and ancient volcanic rocks. This type is best known from the lodes of the Kotsina-Chitina district. These are associated with ancient basaltic lavas, some of which are amygdaloidal and with which some sedimentary beds are intercalated. Conformably above this series is a heavy limestone, near the lower contact occur the most valuable ore bodies that have yet been developed, but some copper occurs throughout the greenstone, and valuable copper lodes have been found in the limestone a long distance from the contact. In general, the most promising deposits have been found along lines of movement which intersected the contact at different angles. It also appears that the plane of the contact between the two formations locally furnished passage for the solutions, even when no movement had taken place. A few deposits that can be classed as fissure veins have been found in this region, but most of the ore bodies are more or less irregularly distributed replacements of the country rock. The openings along which the solution traveled were in many places minute and were probably caused by deformation. The chief ore minerals of these deposits are chalcopyrite, bornite, and chalcocite.

Primary native copper has been found in an amygdaloidal volcanic sheet at the head of the Middle Fork of White River. These deposits are considered primary in the sense that the copper was deposited in the native state in the amygdules and was not the result of the oxidation of sulphides.

Native copper is also found disseminated in the ancient lavas or greenstones of the Kotsina-Chitina and Nabesna-White River regions. The copper is irregularly distributed in fracture zones and is believed to be secondary, possibly being derived from sulphides in the greenstone. Such copper is probably more or less superficial and has not been sufficiently developed to determine its commercial value. It is therefore not here considered as forming a distinct type of ore deposit. With the exception of those deposits, which may be secondary, Alaska copper deposits bear as a rule little evidence of alteration. In most of the copper districts recent glaciation has removed the products of oxidation, and little evidence of enrichment has been found. In some localities the outcrops of the copper sulphides have been changed to copper carbonates, but this is usually only a superficial alteration.

SILVER, LEAD, AND ZINC.

Most of Alaska's silver output (pp. 53–56) has been derived from the silver content of placer gold, but nearly all the gold lodes and many of the copper lodes carry some silver. This is usually in the form of an argentiferous galena, which in some places forms a considerable part of the value of the ore mined. There has been but little development of lodes valuable for their silver and lead alone, though such deposits occur in the Territory. Many of these are replacement deposits in limestone; some are fissure veins. Nearly all of them carry also minor amounts of gold. Fissure veins containing argentiferous galena have been developed in the Ketchikan and Wrangell districts and elsewhere in southeastern Alaska.

Among the many localities where deposits of galena ore have been found in Alaska the Fish River basin, in the eastern part of Seward Peninsula, deserves mention. Some galena deposits have also been found in the western part of Seward Peninsula, in the Fairbanks district, in the Koyukuk basin, and near Mentasta Pass.

No deposits valuable for their zinc content alone have been found in Alaska. Sphalerite is, however, a common accessory mineral in the gold and silver deposits and in some of the copper deposits.

TIN AND TUNGSTEN.

Cassiterite in the form of stream tin is not an uncommon mineral in some of the auriferous gravels of Alaska. It has been systematically mined only in the York district of Seward Peninsula, but some has been recovered incidentally to gold mining in the Hot Springs district of the lower Tanana. Considerable stream tin associated with wolframite, has also been found on Deadwood Creek in the Birch Creek district. Placer tin has also been found on Midnight Creek, in the Ruby district. Lode tin has been reported in the Hot Springs district, but such ore has thus far been mined only in the York district. Here it occurs associated with granitic and porphyritic intrusive rocks. The tin-bearing lodes occur in part in contact-metamorphic zones between slates and granites, in part in mineralized quartz porphyry dikes, and in part in quartz veins cutting granitic slates and limestones. They are therefore, like many of the gold-bearing lodes, closely associated with intrusive granites and allied rocks. Some of these deposits also carry the tungsten minerals wolframite and scheelite. Scheelite has also been found in some of the auriferous gravels and in some small quartz veins on Seward Peninsula.

IRON AND CHROMITE.

Practically no iron ore has been mined in Alaska, and there has been little prospecting for this mineral. Magnetite is abundant in some of the contact copper deposits of the Ketchikan district and occurs in similar association in the Iliamna region. Veins of magnetite ore have been found in the Nabesna and Prince William Sound regions, and the latter contains also some hematite. Magnetite deposits segregated from igneous rocks occur near Haines in southeastern Alaska. None of the Alaska iron ores are sufficiently developed to prove their commercial importance. Chromite occurs in a lode deposit near Port Chatham on Kenai Peninsula. Fragments of chromite ore have also been found in the gold placers of Shungnak in the upper Kobuk basin.

ANTIMONY.

Stibnite, the sulphide of antimony, is one of the most widely distributed minerals in Alaska, for it occurs as an accessory in many of the ore bodies of types already described. There are also some lodes in which stibnite is the dominating metallic mineral. All these stibnite-bearing lodes carry more or less gold, and a number of them probably carry enough gold to warrant classifying them with the auriferous lodes. The geologic association of the stibnite deposits is similar to that of the gold ores.

In southeastern Alaska stibnite has been recognized only as an accessory mineral in some of the gold ores. Quartz veins carrying stibnite have been found on Kenai Peninsula, Prince William Sound, and in the Kantishna and Fairbanks districts; also in Nome and in other districts of Seward Peninsula.

OTHER METALLIC MINERALS.

Nickel and cobalt deposits have been reported by prospectors, but in no samples tested by the Survey were these metals found in commercial quantities. A small amount of nickel and traces of cobalt were found by the analyses of some pyrrhotite ores from the Ketchikan district. Similar tests on pyrrhotite ores from Prince William Sound revealed neither cobalt nor nickel.

No commercial bodies of molybdenite have been found. This mineral occurs in some of the auriferous deposits in the Juneau district, notably at the Treadwell mine. Molybdenite has also been found in quartz stringers which cut the sediments that are altered by igneous metamorphism adjacent to the Coast Range granite belt and to other intrusive masses in the Ketchikan district. It has also been seen as an accessory mineral with the gold ores in other parts of Alaska.

A deposit of native bismuth on which a little development work has been done occurs on Charley Creek, tributary to Sinuk River, about 25 miles north of Nome. The bismuth occurs in two small quartz veins cutting schists.

A cinnabar deposit was discovered near Kolmakof, on the Kuskokwim, many years ago and is a perennial source of attraction to prospectors. This deposit has not been studied by members of the Survey but has recently been developed on a small scale. Cinnabar is found as an accessory mineral in some of the auriferous gravels. It is very abundant in the concentrates from placer mining on Daniels Creek, about 60 miles east of Nome. While the bedrock source of this cinnabar has not been found, it evidently lies at a contact of schist and limestone. Cinnabar is also abundant in placers of Iron Creek, on Seward Peninsula.

A few minute grains of platinum have been found in some of the Alaska gold placers, but as yet not in sufficient quantity to be of commercial importance.

COAL.

Most Alaska coal is associated with conglomerates, shales, and sandstone of Eocene age. Some of these coal measures are little disturbed, and in these the rocks are in many places but slightly indurated, being hardly more than loosely cemented gravels, sands, and silts. In rocks of this type the coals are usually lignitic. Where the rocks have been folded and faulted, they are hard, forming conglomerates, sandstones, and shales. In these the associated coals are of higher grade, varying in composition from subbituminous to anthracite.

Alaska's coal resources range in quality from low-grade lignites to anthracite and include high-grade coking and steaming bituminous coals. The lignite and subbituminous coals are by far the most abundant and most widely distributed. They occur as a rule, as already stated, in beds which are but little disturbed, some lying horizontal and others being gently folded and, in some localities, more or less faulted. The higher-grade coals occur in areas of folding and faulting. As a rule, the quality of the coal bears a direct ratio to the amount of deformation, the lignite being in the least-folded rocks and the anthracite in the most.

The strata carrying high-grade coal have steep dips; in some places the beds are overturned and fractures and faults are common. As a result of these movements much of the coal, particularly the anthracite, is so crushed that briquetting will be necessary. Because of this complex structure and attendant crushing the cost of mining some of the high-grade coal will be prohibitive under present market conditions. These facts are emphasized here because it is sometimes assumed that every bed of high-grade coal is a potential source of wealth. On the other hand, in all the high-grade coal fields there are many localities where coal can be profitably mined when transportation to market is available.

The Matanuska field affords an illustration of the changes in quality of coal due to folding. The southwestern part of the field includes only low-grade coals contained in rocks but little disturbed.

To the northeast and inland the deformation of the coal measures increases and the coals are of better grade. At the east end of the field the beds have been profoundly folded and faulted and the coal is anthracite. There is a similar transition in the Bering River field from bituminous coal near the coast to anthracite in the most profoundly disturbed part of the field.

Although it is sometimes asserted that the age of the coal is the determining factor in quality—that is, that the oldest coals are always the best—such is not the general rule in Alaska. There are, indeed, near Cape Lisburne some high-grade coals of Carboniferous age, but, on the other hand, the Jurassic coals near by are not as good as some of the Tertiary coals which have been described above. It is also not true, as is sometimes stated, that the high grade of some of the Alaska Tertiary coals is due to the effect of igneous intrusion. Igneous rocks are abundant in parts of the Matanuska field, but they have not affected the coal except in some places where it has been altered to a coke. The presence of these igneous rocks will, however, increase the cost of mining.

The Eocene coal-bearing rocks are widely distributed in Alaska. In southeastern Alaska they occur on Admiralty and other islands, but, so far as known, contain little coal. The bituminous and anthracite coal of the Bering River field are in rocks of probably the same age. A great thickness of Eocene coal measures occurs on the west side of Kenai Peninsula, and the same formation is represented on the west side of Cook Inlet, where much of it is buried under gravels. There are some Eocene coal-bearing rocks on the Alaska Peninsula and also some coals of Upper Cretaceous age. Lignite-bearing beds, chiefly of Eocene age, occur on the two slopes of the Susitna Basin, and it is not impossible that much of the Susitna lowland may be underlain by this same formation. The bituminous and anthracite coals of the Matanuska field are also of Eocene age.

The Nenana coal field lies north of the Alaska Range and on the south side of the Tanana Valley. The coals in this field are of Tertiary age but probably post-Eocene. It is not impossible that much of the Tanana lowland may be underlain by this same formation. There is also a belt of coal-bearing rock, probably of Eocene age, paralleling the upper Yukon below the international boundary. Small areas of rocks belonging to the same horizon are known in various parts of the Yukon basin. (See pp. 72–73.) Some coal is reported in the upper White River basin. On the lower Yukon there are some Upper Cretaceous as well as Eocene coals. Coal, probably in the main of Eocene age, is reported at various places in the Kuskokwim basin. There are a few Upper Cretaceous or Eocene coal-bearing rocks in Seward Peninsula and the Kobuk region.

As already noted, coals of Carboniferous and Jurassic age occur in the Lisburne region and in other parts of the Arctic slope, though little is known about them.

Less than one-tenth of Alaska's coal fields have been surveyed in sufficient detail to permit a determination of the actual area of coal land. The results of these surveys are included in the subjoined table. This table includes the lands believed to be underlain by coal but does not attempt to distinguish the deposits that are workable under present conditions. This can be determined only by opening the individual coal beds and thus ascertaining the conditions of mining and the physical character of the coal.

Total known areas of coal lands in Alaska coal fields.

Region.	Square miles.	Acres.
PACIFIC COAST REGION.		
Bering River coal field:		
Anthracite and semianthracite	28.8	18,432
Semibituminous	15.5	9,920
	44.3	28,352
Matanuska coal field:		
Anthracite	4.0	2,560
Semibituminous	52.0	33,280
Bituminous	44.0	28,160
	100.0	64,000
Southeastern Alaska: Lignite	10.0	6,400
Kenai Peninsula and Cook Inlet region: Lignite	282.0	180,480
Alaska Peninsula and southwestern Alaska:		
Bituminous	29.7	19,008
Lignite	31.5	20,160
	61.2	39,168
Susitna basin and Knik region: Lignite	22.0	14,080
INLAND REGION.		
Nenana coal field: Lignite	122.0	78,080
Yukon basin (except Nenana coal field):		
Bituminous	162.0	103,680
Lignite	155.0	99,200
	317.0	202,880
NORTHWESTERN AND NORTHERN ALASKA.		
Seward Peninsula: Lignite	48.5	31,040
Cape Lisburne region:		
Semibituminous	14.2	9,088
Bituminous	205.0	131,200
	219.2	140,288
Northern Alaska:		
Bituminous	9.0	5,760
Lignite	93.0	59,520
	102.0	65,280
RECAPITULATION.		
Anthracite and semianthracite	47.0	30,080
Semibituminous	67.5	43,200
Bituminous	454.7	291,008
Lignite	759.0	485,760
	1,328.2	850,048

In addition to the areas listed above there are about 16,000 square miles of which sufficient is known to indicate that it may be underlain by coal. Most of this additional area of possible coal land will fall in the lignite class. This possible coal land is distributed as follows: Pacific coast region, 8,500 square miles; interior region, 4,500 square miles; Arctic slope region, 3,000 square miles.

PETROLEUM.

Petroleum seepages occur near Katalla, on the Pacific coast, and near Yakataga, 60 miles to the east. At Katalla there has been a small production from two or three wells. The surface rocks of the Katalla field are closely folded and faulted shales and sandstones of Tertiary age. Nothing is known as to the sources of the oil, and it may have its genesis far below the formation exposed at the surface. The Tertiary strata through which the seepages flow are intensely deformed, and the field in this respect is comparable to the oil fields of California. On the other hand, the petroleum is similar in composition to that of Pennsylvania fields. The same geologic conditions prevail at Yakataga, but no drilling has been done there.

Petroleum seepages also occur on the west side of Cook Inlet near Iniskin Bay. Here the rocks are Jurassic sediments, chiefly shales and sandstones. These rocks lie in broad open folds, a condition favorable to petroleum accumulation, but on the other hand they are broken by faults. Similar conditions prevail at Cold Bay, 160 miles to the southwest, where petroleum seepages also occur. A little drilling has been done in both these fields, but not enough to prove the presence or absence of commercial oil pools.

Some petroleum residue has been found near the south end of Smith Bay, an indentation on the Arctic coast of Alaska about 60 miles east of Point Barrow. This would indicate the presence of oil seepage, but nothing is known about the geology of the region.

Alaska petroleum, so far as its composition is known, is a refining oil with a paraffin base and a low sulphur content. That which is now being produced near Katalla is refined in a small plant and the gasoline locally marketed. There is no inherent reason why petroleum may not occur in some of the sedimentary rocks of parts of Alaska other than those where it reaches the surface through seepage. Such occurrence is, however, not to be expected in regions of metamorphism or extensive igneous intrusion. While petroleum may occur at depth and not reach the surface through seepage, yet there is now no information to guide the driller. Therefore, if any drilling is to be done, it will first be advisable to search out those areas where the presence of seepages gives best hope of favorable results.

PEAT.

Peat occurs in nearly every part of Alaska except in the high ranges. The humidity of the Pacific coastal zone and the consequent luxuriant vegetation favors its accumulation. Southeastern Alaska is heavily forested and in many places has a dense growth of underbrush with a flooring of moss. In southwestern Alaska timber is entirely absent but all the lowland and much of the upland regions are covered with moss, grass, and small shrubbery. The prevailing humidity in both these districts favors the accumulation of vegetable refuse. Though there has been no prospecting for peat in this part of the Territory, deposits at least 15 to 20 feet in thickness are known and some of them are believed to be of good quality.

Central and northern Alaska have a much smaller precipitation. Here, however, the soil is nearly everywhere mantled by a dense blanket of moss and other vegetation. This is especially striking in the extensive timberless areas or tundras which lie along Bering Sea and the Arctic Ocean. In these two provinces the subsoil is usually frozen, and the rain water is retained at the surface. The moss, except in excessively dry weather, is usually saturated with water. All these conditions, which promote vegetable growth and retard evaporation and oxidation, are favorable to the formation of peat. As a matter of fact, there is nearly everywhere a layer of peaty material underneath the soil. Some natural exposures reveal peat deposits having a depth of 30 to 40 feet. While the widespread surface layer of peat is of an inferior quality, some of the deeper-lying beds are probably of higher grade. No data whatever are at hand to estimate the available supply of peat, but as it is found in every part of Alaska and under the great tundras of the north, which form at least a quarter of the Territory, the total supply must be large and possibly exceeds that of the entire United States. It is not known what part of this peat is in beds thick enough and of proper quality to be utilized.

Owing to the presence of more easily available fuel there has been little occasion to utilize any of the peat beds, so practically nothing is known of their fuel value, extent, or thickness, except what has been stated. One of the few deposits of this mineral fuel in Alaska that have been exploited is a peat bed saturated with petroleum residue near Cold Bay, on the Alaska Peninsula, where some years ago the material was used for fuel at the neighboring oil drills. Here, however, it is the petroleum residue rather than the peat which gives the deposit its chief value. A little peat has also been dug and dried for fuel at St. Michael, Nome, and Fairbanks. In the absence of better and cheaper fuel at some places the peat beds will undoubtedly be locally utilized. Where good lignitic or higher-grade coals are available peat will not be used.

STRUCTURAL MATERIAL.

Considerable marble quarrying has been done in southeastern Alaska, and there are also a number of undeveloped occurrences of marble in this region. All the developed deposits occur at or near tidewater, no search having been made for marble in inland regions where high transportation costs would prohibit exploitation. Several varieties have been found among the marbles exploited. The most common variety in southeastern Alaska is a finely crystalline white to bluish-gray marble with gray to dark-bluish veins and clouded areas. Another kind also found in southeastern Alaska but little exploited is a crystalline marble which shows handsome "verde antique" effects and other striking combinations of color, such as green and pink, black and white, and white and yellow.

The marbles are altered limestones, the metamorphism being due for the most part to the intrusion of igneous rocks. They are all believed to be of Paleozoic age. Crystallized limestones are known in other parts of the Territory as well as in southeastern Alaska. Many of these beds are too shattered to yield structural material, but others might be of value if located on tidewater.

The only gypsum deposit that has been found in the Territory occurs in the eastern part of Chichagof Island, in the Sitka district. This deposit, which lies close to tidewater, has been mined for several years. The gypsum is associated with cherty limestones of upper Carboniferous age, but the deposit itself may be younger. There is no inherent reason why gypsum should be found only at this one locality.

Limestones and shales occurring in many parts of Alaska afford a possible source of material for the manufacture of cement. None of these has been tested, and even if they were found suitable they could be utilized only where proper fuel is available.

Granite and allied rocks are widely distributed in Alaska. They are especially abundant in southeastern Alaska, where water transportation is cheap. If any demand arises for building stone, some of these occurrences should yield suitable material.

MISCELLANEOUS NONMETALLIC MINERALS.

A little garnet mining has been carried on near Wrangell, in southeastern Alaska. The garnets at this locality are dark in color and occur in crystalline schist, probably of Mesozoic age. Garnets also occur in the metamorphic schists of the Kigluaik Mountains on Seward Peninsula, where a few have been mined. A little jade has been recovered from the Noatak-Kobuk region.

There are some deposits of graphite-bearing schists in the Kigluaik Mountains of Seward Peninsula, about 50 miles north of Nome. Some of this graphite has possible commercial importance and a few small shipments have been made. A deposit of barite has been found in the Wrangell district of southeastern Alaska.

Asbestos occurs in the Yukon-Tanana region and the Kobuk basin but has not been found in commercial quantities. Workable deposits of mica have been reported to be present in the Susitna basin and in the Council district of Seward Peninsula.

There are some sulphur deposits around the volcanic vents of southwestern Alaska. A sulphur deposit on Makushkin Volcano, on Unalaska Island, was investigated several years ago with a view to commercial development. The results of this work have not been made public, but the enterprise has not been advanced. Some of the volcanic ash or tuff ejected from the eruption of Mount Katmai on June 6 to 8, 1912, has possible value for use as an abrasive. There is an abundance of this material, the most accessible deposit being that on the shores of Amalik Bay, Alaska Peninsula, where it is 20 feet or more in thickness. A few small shipments of this material have been made.

WATER RESOURCES.

The waters of Alaska can be grouped as surface, ground, and spring water. Surface water is the most valuable, chiefly to furnish power for mining and other industries but also for the use of towns and settlements. Ground waters occur in the Pacific slope region, but as there is an ample supply of surface water they have not been used. In the semiarid regions of the interior, where in some localities the surface water supply is scant, ground water is also not abundant. In this province much of the subsoil is permanently frozen and does not permit water circulation. In some places, however, there is a ground-water circulation below the zone of permanent frost and sometimes within the zone. It is possible that this ground water may in places be sufficient in quantity to have value for local use.

Twenty hot springs are known in Alaska, distributed as follows: Southeastern Alaska, 7; Alaska Peninsula, 2; Yukon basin, 7; Seward Peninsula, 2; Kobuk, 1; Selawik, 1. Mineral springs are also widely distributed, and a little mineral water was formerly exported from southeastern Alaska. Small sanitariums built at a number of hot springs have been an important element in the hygienic life of the people. Some of the hot springs have been used as health resorts, even where no permanent sanitarium had been erected. Hot springs are known in southeastern and southwestern Alaska, in the Yukon basin, and in Seward Peninsula.

The Pacific coastal region, with its high precipitation and strong relief, has many water powers. It should be noted, however, that the run-off is very much reduced during the winter. The best sources of power in this province are the lakes, which afford conditions for less annual fluctuation than the streams. Only in southeastern Alaska has there been any considerable water-power development. For use in mining a total of 7,374 horsepower was developed by water wheels in Alaska in 1910.[1] This has since then been much increased. There are a number of promising water powers in the lower Copper River basin, in the Prince William Sound, Susitna, and Matanuska regions, and on Kenai Peninsula. There are also a number of water powers in the lake region of Iliamna.

In the Yukon region and in Seward Peninsula low stream gradients are the rule, and this condition, with the low precipitation, is unfavorable to the use of water under head. Nevertheless, even in these regions there is in the aggregate much water available for placer mining, and indeed much of this is now in use. In the higher parts of these provinces there are also some water powers, but these are undeveloped.

---

[1] Thirteenth Census, Reprint of Supplement for Alaska, p. 606, 1912.

THE ALASKAN MINING INDUSTRY IN 1913.

By Alfred H. Brooks.

GENERAL CONDITIONS.

Measured by value of output the Alaskan mining industry was less prosperous in 1913 than in 1912. Extensive developments were continued during the year in some of the gold-lode districts, notably at Juneau and to a lesser extent at Willow Creek and Fairbanks. This activity, consisting chiefly of underground dead work and of the installation of mills, has not yet contributed in any large measure to the gold production, and therefore two-thirds of Alaska's gold output still comes from the placer mines. Less than 40 per cent of the placer gold is produced by large plants, the rest being still won from the rich gravels that can be profitably mined by hand methods. Therefore marked fluctuation in the placer-gold output is inevitable, being due to the exhaustion of bonanzas on one hand and the discovery of new districts on the other. Moreover, these small operations are far more dependent on the local water supply than the large plants. Under such conditions no stability in the production of placer gold is to be expected. A shortage of water is almost a perennial condition in many of the placer camps, where large operations are attempted. Every four or five years there are unusually dry seasons, which may almost entirely curtail all operations except dredging. Such conditions prevailed in 1913 in the Yukon districts, in the Iditarod-Innoko region, and on Seward Peninsula. These conditions, together with the approaching exhaustion of the bonanza deposits of the Fairbanks district, account for the decrease in gold output. It must not be considered from the above statements that there is any shortage of auriferous gravels, but only of those that can be profitably mined under the present high operating cost. New areas of placer ground that could be profitably exploited by dredges, if transportation charges were reduced, are constantly being discovered. Moreover, the installation of dredges in the more accessible parts of Seward Peninsula has continued as in previous years. Deposits of auriferous gravels were found in 1913 in two new and widely separated localities—the upper Matanuska basin and the upper basin of the Chisana (locally called Shushana), a tributary of the Tanana. What is true of the cost of placer mining applies also to lode mining, except on tidewater. The Fairbanks district has shown what can be accomplished in lode mining under the most adverse conditions of transportation, labor, water, and fuel. Mining in the coastal region is developing at so rapid a rate that it bids fair to overshadow all mining operations in the interior, and no marked progress can be expected in the inland region until a transportation system is provided.

The falling off in copper output is less significant, because it is due solely to the fact that the Kennecott-Bonanza—much the largest copper producer—was closed down, on account of accidents, for about one-third of the year. Tin mining continued in the York region of Seward Peninsula and some prospecting of tin deposits was done in the Hot Springs district of the Tanana Valley. One lignite mine was operated on Cook Inlet, the only one developed on a commercial basis in the entire Territory. The Katalla field produced some oil in 1913, and gypsum and marble deposits were worked in southeastern Alaska, as in previous years.

PRODUCTION.

The value of the total mineral production in 1913 is estimated at $19,416,294; in 1912 it was $22,566,484. The statistics for 1913 are not complete, and the figures given in the subjoined table may be subject to slight change. The output of marble, tin, gypsum, lead, and other minor products is given under a single item, because separate listing might reveal the production of individual properties.

Mineral production of Alaska, 1912–13.

	1912		1913		Increase (+) or decrease (−).	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold............fine ounces..	829,435	$17,145,951	755,947	$15,626,813	− 73,488	−$1,519,138
Silver..................do....	515,186	316,839	362,563	218,988	− 152,623	− 97,851
Copper.............pounds..	29,230,491	4,823,031	21,659,958	3,357,293	−7,570,533	− 1,465,738
Coal...........short tons..	200	2,000	[a] 2,300	[a] 13,200	+ 2,100	+ 11,200
Marble, gypsum, tin, lead, petroleum, etc............	....	277,823	....	[a] 200,000	....	− 77,823
	....	22,565,644	....	19,416,294	....	− 3,149,350

[a] Preliminary estimate.

NOTE.—In the above table copper is valued at 16.5 cents a pound for 1912 and 15.5 cents for 1913; silver at 61.5 cents an ounce for 1912 and 60.4 cents for 1913.

Mining began in 1880, but for many years no very accurate record of mineral output was kept. Since 1905, however, fairly reliable statistics of mineral production are available. These data are summarized in the following table, both by years and by substances:

Value of total mineral production of Alaska, 1880–1913.

By years.				By substances.	
1880–1890	$4,686,714	1902	$8,400,693	Gold	$228,392,540
1891	916,920	1903	8,941,614	Silver (commercial value)	2,060,191
1892	1,096,000	1904	9,567,535	Copper	16,927,518
1893	1,048,570	1905	16,478,142	Coal	360,589
1894	1,305,257	1906	23,375,008	Marble, gypsum, tin, etc	1,210,377
1895	2,386,722	1907	20,847,055		248,951,215
1896	2,980,087	1908	20,142,272		
1897	2,538,241	1909	21,141,019		
1898	2,585,575	1910	16,887,244		
1899	5,703,076	1911	20,691,241		
1900	8,238,294	1912	22,565,644		
1901	7,007,398	1913	[a] 19,416,294		
			248,951,215		

[a] Preliminary estimate.

TRANSPORTATION.

There was no railway construction in Alaska during 1913. In view of the present interest in Alaskan railways concise data regarding existing lines are presented in the following table:

Railways in Alaska.

	Miles.
Southeastern Alaska:	
White Pass & Yukon route, Skagway to White Pass (narrow gage). Terminal at White Horse, Yukon Territory; total mileage, 102 miles	20.4
Yakutat Southern Railway, Yakutat to Situk River (narrow gage) (not a public carrier)	9.0
Copper River: Copper River & Northwestern Railway, Cordova to Kennicott (standard gage)	195.0
(The same company has built a few miles of track at Katalla, where the Alaska Pacific Railway was laid in 1907, and some work was previously done at Valdez, on the Copper River & Northwestern Railway, on the Valdez & Yukon Railway, and on the Alaska Home Railway.)	
Kenai Peninsula: Alaska Northern Railway, Seward to a point near head of Turnagain Arm (standard gage) [1]	71.6
Yukon basin: Tanana Valley Railway, Fairbanks and Chena to Chatanika (narrow gage)	46.0
Seward Peninsula:	
Seward Peninsula Railway, Nome to Shelton (narrow gage) [1]	80.0
Paystreak branch, Seward Peninsula Railway (narrow gage) [1]	6.5
Council City & Solomon River Railway, Council to Penelope Creek (standard gage) [1]	32.5
Wild Goose Railway, Council to Ophir Creek (narrow gage) [1]	5.0
	466.0

Of these only the White Pass & Yukon, the Copper River & Northwestern, and the Tanana Valley railways, aggregating 261.4 miles of track, were operated as public carriers in 1913. A gasoline car was operated under a cooperative agreement by a citizens' com-

---

[1] Not operated as public carrier in 1913.

mittee of Seward for about 34 miles on the Alaska Northern Railway. On some of the Seward Peninsula railways freight was hauled by dog teams. This private operation of the lines was undertaken because the railway companies could not afford to pay the tax on public carriers.

In August, 1912, provision was made by law for a commission to investigate railway routes in Alaska and general conditions of transportation. The report[1] of the commission was submitted to the President on January 20, 1913. As a result, Congress gave the matter serious consideration, and a law providing for Government railways in Alaska was enacted on March 12, 1914. As this law is of great importance to the mining industry, it is here printed in full.

AN ACT To authorize the President of the United States to locate, construct, and operate railroads in the Territory of Alaska, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the President of the United States is hereby empowered, authorized, and directed to adopt and use a name by which to designate the railroad or railroads and properties to be located, owned, acquired, or operated under the authority of this act; to employ such officers, agents, or agencies, in his discretion, as may be necessary to enable him to carry out the purposes of this act; to authorize and require such officers, agents, or agencies to perform any or all of the duties imposed upon him by the terms of this act; to detail and require any officer or officers in the Engineer Corps in the Army or Navy to perform service under this act; to fix the compensation of all officers, agents, or employees appointed or designated by him; to designate and cause to be located a route or routes for a line or lines of railroad in the Territory of Alaska not to exceed in the aggregate one thousand miles, to be so located as to connect one or more of the open Pacific Ocean harbors on the southern coast of Alaska with the navigable waters in the interior of Alaska, and with a coal field or fields so as best to aid in the development of the agricultural and mineral or other resources of Alaska, and the settlement of the public lands therein, and so as to provide transportation of coal for the Army and Navy, transportation of troops, arms, munitions of war, the mails, and for other governmental and public uses, and for the transportation of passengers and property; to construct and build a railroad or railroads along such route or routes as he may so designate and locate, with the necessary branch lines, feeders, sidings, switches, and spurs; to purchase or otherwise acquire all real and personal property necessary to carry out the purposes of this act; to exercise the power of eminent domain in acquiring property for such use, which use is hereby declared to be a public use, by condemnation in the courts of Alaska in accordance with the laws now or hereafter in force there; to acquire rights of way, terminal grounds, and all other rights; to purchase or otherwise acquire all necessary equipment for the construction and operation of such railroad or railroads; to build or otherwise acquire docks, wharves, terminal facilities, and all structures needed for the equipment and operation of such railroad or railroads; to fix, change, or modify rates for the transportation of passengers and property, which rates shall be equal and uniform, but no free transportation or passes shall be permitted except that the provisions of the interstate commerce laws relating to the transportation of employees and their families shall be in force as to the lines constructed under this act; to receive compensation for the transportation of passengers and property, and to perform generally all the usual duties of a common carrier by railroad; to make and establish rules and regu-

---

[1] Railway routes in Alaska: 62d Cong., 3d sess., H. Doc. 1346, pts. 1 and 2, 1913.

lations for the control and operation of said railroad or railroads; in his discretion, to lease the said railroad or railroads, or any portion thereof, including telegraph and telephone lines, after completion under such terms as he may deem proper, but no lease shall be for a longer period than twenty years, or in the event of failure to lease, to operate the same until the further action of Congress: *Provided*, That if said railroad or railroads, including telegraph and telephone lines, are leased under the authority herein given, then and in that event they shall be operated under the jurisdiction and control of the provisions of the interstate commerce laws; to purchase, condemn, or otherwise acquire upon such terms as he may deem proper any other line or lines of railroad in Alaska which may be necessary to complete the construction of the line or lines of railroad designated or located by him: *Provided*, That the price to be paid in case of purchase shall in no case exceed the actual physical value of the railroad; to make contracts or agreements with any railroad or steamship company or vessel owner for joint transportation of passengers or property over the road or roads herein provided for, and such railroad or steamship line or by such vessel, and to make such other contracts as may be necessary to carry out any of the purposes of this act; to utilize in carrying on the work herein provided for any and all machinery, equipment, instruments, material, and other property of any sort whatsoever used or acquired in connection with the construction of the Panama Canal, so far and as rapidly as the same is no longer needed at Panama, and the Isthmian Canal Commission is hereby authorized to deliver said property to such officers or persons as the President may designate, and to take credit therefor at such percentage of its original cost as the President may approve, but this amount shall not be charged against the fund provided for in this act.

The authority herein granted shall include the power to construct, maintain, and operate telegraph and telephone lines so far as they may be necessary or convenient in the construction and operation of the railroad or railroads as herein authorized and they shall perform generally all the usual duties of telegraph and telephone lines for hire.

That it is the intent and purpose of Congress through this act to authorize and empower the President of the United States, and he is hereby fully authorized and empowered, through such officers, agents, or agencies as he may appoint or employ, to do all necessary acts and things in addition to those specially authorized in this act to enable him to accomplish the purposes and objects of this act.

The President is hereby authorized to withdraw, locate, and dispose of, under such rules and regulations as he may prescribe, such area or areas of the public domain along the line or lines of such proposed railroad or railroads for town-site purposes as he may from time to time designate.

Terminal and station grounds and rights of way through the lands of the United States in the Territory of Alaska are hereby granted for the construction of railroads, telegraph and telephone lines authorized by this act, and in all patents for lands hereafter taken up, entered, or located in the Territory of Alaska there shall be expressed that there is reserved to the United States a right of way for the construction of railroads, telegraph and telephone lines to the extent of one hundred feet on either side of the center line of any such road and twenty-five feet on either side of the center line of any such telegraph or telephone lines, and the President may, in such manner as he deems advisable, make reservation of such lands as are or may be useful for furnishing materials for construction and for stations, terminals, docks, and for such other purposes in connection with the construction and operation of such railroad lines as he may deem necessary and desirable.

SEC. 2. That the cost of the work authorized by this act shall not exceed $35,000,000, and in executing the authority granted by this act the President shall not expend nor obligate the United States to expend more than the said sum; and there is hereby appropriated, out of any money in the Treasury not otherwise appropriated, the sum of $1,000,000 to be used for carrying out the provisions of this act, to continue available until expended.

SEC. 3. That all moneys derived from the lease, sale, or disposal of any of the public lands, including town sites, in Alaska, or the coal or mineral therein contained, or the timber thereon, and the earnings of said railroad or railroads, together with the earnings of the telegraph and telephone lines constructed under this act, above maintenance charges and operating expenses, shall be paid into the Treasury of the United States as other miscellaneous receipts are paid, and a separate account thereof shall be kept and annually reported to Congress.

SEC. 4. That the officers, agents, or agencies placed in charge of the work by the President shall make to the President annually, and at such other periods as may be required by the President or by either House of Congress, full and complete reports of all their acts and doings and of all moneys received and expended in the construction of said work and in the operation of said work or works and in the performance of their duties in connection therewith. The annual reports herein provided for shall be by the President transmitted to Congress.

Approved, March 12, 1914.

Early in May the appointment of the Alaskan Engineering Commission, for the purpose of carrying out the provisions of the above act, was officially announced. The members of this commission are William C. Edes, Lieut. Frederick Meares, United States Army, and Thomas Riggs, jr. Surveys of railway routes have been begun by the commission.

In 1913 both official topographic and private railway surveys were made across the neck of land which separates the head of Turnagain Arm from Passage Canal (locally known as Portage Bay), a western arm of Prince William Sound. Mr. Giffin, of the Geological Survey, made a topographic reconnaissance of this region (Pl. II), and a party of the Coast and Geodetic Survey made soundings of the head of Passage Canal, mapped the adjacent shore line, and carried the mapping across the first divide. The private railway survey was run from the head of Passage Canal to Turnagain Arm. All this information points to the conclusion that, with one 2-mile tunnel and a second tunnel or rock cut half a mile in length, a railway can be built across this divide which will avoid all glaciers, with a maximum grade not exceeding 0.3 per cent for both inward and outward bound traffic. The distance by this route from tidewater on Passage Canal to mile 64 on the Alaska Northern Railway is about 10.5 miles. Official information as to conditions of navigation, wind, etc., on Passage Canal are lacking at this writing. The topography and nearness of Portage Glacier suggest that strong winds will probably blow on Passage Canal at certain times in the year.

These facts are here set forth, because if the Portage Glacier route proves feasible for a railway, it will be of great importance to the mining industry, for it will give the Matanuska coal an outlet to an open harbor on Prince William Sound with only a slight grade to overcome.

1
s
r
T
o
t
l
G
C

p
in
h

The distance from the coal field to tidewater by this route is about 125.5 miles. It will not be necessary to discuss here the possible effect of the use of this route on other inland mining districts.

As this new route may become of much importance to the mining industry it will be of interest to record briefly the history of its exploration. As far back as 1794 the English navigator Capt. George Vancouver reported that the Russians had long used the Portage Glacier as a route from Prince William Sound to Turnagain Arm. It was frequently used by prospectors up to about 1907, when the completion of the Alaska Northern Railway gave more easy access to Turnagain Arm. The first official survey of the Portage Glacier region was made in 1898, when Capt. (now Col.) E. F. Glenn, United States Army, sent a party from Passage Canal across Portage Glacier to Turnagain Arm. While Col. Glenn in his report does not specifically state that the Portage Glacier route was not feasible for a railway, the logical inference from his statements[1] is to that effect. Moreover, the map illustrating these explorations and accompanying the volume indicates that no railway route is available unless a tunnel under a glacier were feasible. Mendenhall,[2] who accompanied the Glenn expedition as geologist, also makes no mention of the feasibility of the Portage Glacier route for a railway.

In 1899 Glenn again took up explorations in this region, the subparty being under the command of Capt. (now Maj.) Joseph S. Herron, United States Army. Herron crossed from Passage Canal by a route lying 10 miles north of Portage Glacier and therefore did not see the proposed railway route and makes no mention of it in his report.[3]

It could hardly be expected that the explorations above cited could definitely determine the feasibility of this route, for the surveys were only hasty reconnaissances made early in the spring, when the valleys were deeply buried in snow. Moreover, the examinations of the Portage Glacier route were only incidental to more extended inland explorations. It is probable that, because of the snow, the absence of ice from the valley lying inland of the first ridge west of the head of the Passage Canal was not noted by the Glenn party. It is this ice-clear valley which makes the route feasible for a railway. No other official surveys than those recorded above had been made of this pass when the Alaska Railroad Commission made its report; hence it reported[4] that this route was probably not feasible. While the official data available to the commission were all unfavorable to

---

[1] Reports of explorations in the Territory of Alaska (Cook Inlet, Susitna and Copper rivers), War Dept., Adjt. General's Office, pp. 103-104, 110, Washington, 1899.

[2] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 300-301, 1900.

[3] Herron, J. S., Exploration in Alaska in 1899, War Dept., Adjt. General's Office, No. 31, Washington, 1901.

[4] Railway routes in Alaska: 62d Cong., 3d sess., H. Doc. 1346, p. 82, 1913.

this route, it had been advocated by a number of persons more or less familiar with the general region. Several years ago Mr. George Palmer, who has lived in the Cook Inlet region for more than 20 years, told the writer of the Portage Glacier railway route but could not give any detailed account of it. Mr. Henry Deyo, an experienced railway engineer of Valdez, expressed an opinion of the feasibility of this route in 1912, but at that time he had not seen it himself. The same year Tarr and Martin, who had been studying the glaciers of Prince William Sound and Kenai Peninsula, prepared a report[1] in which they advocated the Portage Glacier route for a railway. Their publication, however, gave no evidence that they had personally examined the route. The Alaska Railroad Commission had no time to verify these reports, and in the opinion of the writer was fully justified in stating, as it did, that the route was probably not feasible.

Wagon road and trail construction was continued by the Board of Road Commissioners[2] for Alaska, and up to the close of the fiscal year 1913 a total of 862 miles of wagon road, 617 miles of winter sled road, and 2,167 miles of trail was completed. The need of more wagon roads for the development of mineral resources has long been recognized by those familiar with the conditions of transportation. Railway construction is of first importance to the Territory, and second only to this is the building of a system of tributary wagon roads.

There is little else to record in the improvement of transportation in the Territory. More aids to navigation have been installed, but the facilities are still entirely inadequate to the needs of the merchant marine. Communication with Fairbanks was somewhat improved. During the summer several automobile trips were made over the military wagon road from Chitina to Fairbanks. A new direct steamboat service was established between upper Yukon points and Fairbanks.

METAL MINING.

PRODUCTION.

In 1913 about 31 per cent of the total production of gold came from lode mines, the balance from placer mines. The output of lode gold in 1912 was about 29 per cent of the total; in 1911 it was 24 per cent. This indicates a gradual transition from placer to lode mining. A decrease in placer mining must be expected until railways have so reduced the cost of operation as to make the less valuable auriferous gravels available to profitable exploitation. In the following table, based in part on preliminary estimates, the production of precious metals has been distributed as to sources:

---

[1] Tarr, R. S., and Martin, Lawrence, An effort to control a glacial stream: Assoc. Am. Geographers Annals, vol. 2, pp. 38-39, 1912.

[2] Richardson, W. P., Lieut. Col., Report of Road Commissioners for Alaska, 1913.

Sources of gold, silver, and copper in Alaska, 1913, by kinds of ore.

	Total quantity.	Gold.		Silver.		Copper.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	*Fine oz.*		*Fine oz.*		*Pounds.*	
Siliceous ores	1,614,506	232,916.58	$4,814,813	30,897	$18,662		
Copper ores	135,756	6,385.50	132,000	273,179	165,000	21,659,958	$3,357,293
Placers		516,645.00	10,680,000	58,487	35,326		
	1,750,262	755,947.08	15,626,813	362,563	218,988	21,659,958	3,357,293

To arrive at the total metal production the value of the tin output, not here published, should be added. A small amount of lead is also recovered each year incidentally to the treatment of other ores. In the following table the production of gold, silver, and copper is given by years:

Production of gold, silver, and copper in Alaska, 1880–1913.

Year.	Gold.		Silver.		Copper.	
	Quantity.	Value.	Quantity.	Commercial value.	Quantity.	Value.
	Fine ounces.		*Fine ounces.*		*Pounds.*	
1880	967	$20,000			3,933	$826
1881	1,935	40,000				
1882	7,256	150,000				
1883	14,561	301,000	10,320	$11,146		
1884	9,723	201,000				
1885	14,512	300,000				
1886	21,575	446,000				
1887	32,653	675,000				
1888	41,119	850,000	2,320	2,181		
1889	43,538	900,000	8,000	7,490		
1890	36,862	762,000	7,500	6,071		
1891	43,538	900,000	8,000	7,920		
1892	52,245	1,080,000	8,000	7,000		
1893	50,213	1,038,000	8,400	6,570		
1894	62,017	1,282,000	22,261	14,257		
1895	112,642	2,328,500	67,200	44,222		
1896	138,401	2,861,000	145,300	99,087		
1897	118,011	2,439,500	116,400	70,741		
1898	121,760	2,517,000	92,400	54,575		
1899	270,997	5,602,000	140,100	84,276		
1900	395,030	8,166,000	73,300	45,494		
1901	335,369	6,932,700	47,900	28,598	250,000	40,000
1902	400,709	8,283,400	92,000	48,590	360,000	41,400
1903	420,069	8,683,600	143,600	77,843	1,200,000	156,000
1904	443,115	9,160,000	198,700	114,934	2,043,586	275,676
1905	756,101	15,630,000	132,174	80,165	4,805,236	749,617
1906	1,066,030	22,036,794	203,500	136,345	5,871,811	1,133,260
1907	936,044	19,349,743	149,784	98,857	6,308,786	1,261,757
1908	933,290	19,292,818	135,672	71,906	4,585,362	605,267
1909	987,417	20,411,716	147,950	76,934	4,124,705	536,211
1910	780,131	16,126,749	157,850	85,239	4,241,689	538,695
1911	815,276	16,853,256	460,231	243,923	27,267,878	3,408,485
1912	829,435	17,145,951	515,186	316,839	29,230,491	4,823,031
1913	755,947	15,626,813	362,563	218,988	21,659,958	3,357,293
	11,048,488	228,392,540	3,456,601	2,060,191	111,954,435	16,927,518

In the following table the total gold production is distributed according to districts, so far as the information at hand will permit. The error in distribution for the production previous to the year 1905, when the systematic collection of statistics of Alaska's mineral output was begun, is believed to be less than 15 per cent. Complete statistical returns from all producers are not even now available, so that there is probably still some error in the distribution of the totals to the various districts. This error is, however, believed to be less than 3 per cent, and it is hoped that in future it may be eliminated altogether.

The production from the Pacific coast belt is derived principally from the lode mines of southeastern Alaska but includes also the output of the lode mines of Prince William Sound and southwestern Alaska, as well as a small output from gold placers. Previous to 1885 the placers of the Juneau district yielded considerable gold, and since 1899 the Porcupine district of southeastern Alaska has been a small producer. The beach placers along the Pacific seaboard have been worked spasmodically since about 1890.

Up to 1909 all the gold from the Copper River and Cook Inlet region was derived from gold placers; since then there has been an output from the auriferous lodes of Willow Creek and Kenai Peninsula. The gold output of Seward Peninsula is practically all derived from placers, but there has been a little lode mining. Since 1910 there has been a small lode production from the Fairbanks district, which in 1913 amounted to about 9.5 per cent of the total.

Value of gold production of Alaska, with approximate distribution, 1880–1913.

Year.	Pacific coast belt.	Copper River and Cook Inlet region.	Yukon basin.	Seward Peninsula and northwestern Alaska.	Total.
1880	$20,000				$20,000
1881	40,000				40,000
1882	150,000				150,000
1883	300,000		$1,000		301,000
1884	200,000		1,000		201,000
1885	275,000		25,000		300,000
1886	416,000		30,000		446,000
1887	645,000		30,000		675,000
1888	815,000		35,000		850,000
1889	860,000		40,000		900,000
1890	712,000		50,000		762,000
1891	800,000		100,000		900,000
1892	970,000		110,000		1,080,000
1893	838,000		200,000		1,038,000
1894	882,000		400,000		1,282,000
1895	1,569,500	$50,000	709,000		2,328,500
1896	1,941,000	120,000	800,000		2,861,000
1897	1,799,500	175,000	450,000	$15,000	2,439,500
1898	1,892,000	150,000	400,000	75,000	2,517,000
1899	2,152,000	150,000	500,000	2,800,000	5,602,000
1900	2,606,000	160,000	650,000	4,750,000	8,166,000
1901	2,072,000	180,000	550,000	4,130,700	6,932,700
1902	2,546,600	375,000	800,000	4,561,800	8,283,400
1903	2,843,000	375,000	1,000,000	4,465,600	8,683,600
1904	3,195,400	500,000	1,300,000	4,164,600	9,160,000
1905	3,430,000	500,000	6,900,000	4,800,000	15,630,000
1906	3,454,794	332,000	10,750,000	7,500,000	22,036,794
1907	2,891,743	275,000	9,183,000	7,000,000	19,349,743
1908	3,448,318	401,500	10,323,000	5,120,000	19,292,818
1909	4,264,716	265,000	[a] 11,580,000	4,302,000	20,411,716
1910	4,182,730	351,630	[a] 8,062,389	3,530,000	16,126,749
1911	4,265,573	313,538	[a] 9,139,145	3,135,000	16,853,256
1912	4,904,753	358,401	[a] 8,857,797	3,025,000	17,145,951
1913	4,529,529	378,643	[a] 8,183,641	2,535,000	15,626,813
	65,912,156	5,410,712	91,159,972	65,909,700	228,392,540

[a] Includes a small production from the Kuskokwim basin.

The production given for the Yukon basin includes, of course, only that from the Alaska camps. Mining has been carried on in the Canadian Yukon since 1885; the output of this region is presented in the next table. Since 1910 some placer gold has been derived from the lower Kuskokwim basin; this is included with the Yukon gold production in the above table.

Production of gold in Yukon districts, Canada, 1885–1913.[a]

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Fine ounces.			*Fine ounces.*	
1885	4,387	$100,000	1901	870,750	$18,000,000
1887	3,386	70,000	1902	701,437	14,500,000
1888	1,935	40,000	1903	592,594	12,250,000
1889	8,466	175,000	1904	407,938	10,500,000
1890	8,466	175,000	1905	381,001	7,876,000
1891	1,935	40,000	1906	270,900	5,600,000
1892	4,233	87,500	1907	152,381	3,150,000
1893	8,514	176,000	1908	174,150	3,600,000
1894	6,047	125,000	1909	191,565	3,960,000
1895	12,094	250,000	1910	220,166	4,550,000
1896	14,513	300,000	1911	224,197	4,634,574
1897	120,937	2,500,000	1912	268,447	5,549,296
1898	483,750	10,000,000	1913 [b]	352,900	5,835,554
1899	774,000	16,000,000			
1900	1,077,563	22,275,000		7,338,642	152,318,924

[a] From reports of Mines Branch, Dept. Mines, Ottawa, Canada. [b] Preliminary estimate.

This table is here included because the variation in gold output well illustrates the normal evolution of a placer-mining district. The output of gold to and including 1896 is that of the pioneer who operated before the richest deposits had been found. The high production from 1897 to 1904 represents the recovery of gold from the bonanza deposits mined without the use of elaborate equipment. From 1905 to 1908 there was a marked decline in output due to the fact that the rich placers had been mined out and the equipment for exploiting the gravels of lesser gold tenor had not yet been installed. Since 1908 the gold output has steadily increased as a result of dredging and hydraulicking. A similar sequence of events is to be expected in the Alaskan placer districts, most of which are at present on the decline owing to the fact that the richest deposits are approaching exhaustion. With the decrease in cost of installation and operation that will follow railway construction an increase of the placer-gold output will take place.

GENERAL FEATURES.

The total production of gold from the auriferous lode mines of Alaska since 1882 is estimated to be 28,199,538 fine ounces, valued at $62,628,113. These mines have also produced 1,096,336 fine ounces of silver, having a commercial value of $667,516. It is estimated that since mining began in 1880 Alaskan gold placers have yielded 8,005,136 fine ounces of gold, valued at $165,480,848. These mines have also produced 1,610,503 fine ounces of silver, having a commercial value of $996,069. The total production of copper from the Alaskan mines up to the close of 1913 was 111,954,455 pounds, valued at $16,927,518. Most of this copper has been produced since 1901, when systematic mining of this ore began.

Tin mining began in 1902, when the tin placers of the York district were developed in a small way. In the last three years the annual output of tin has been much increased by dredging operations. There has also been a small output of lode tin. The total production up to the close of 1913 is estimated to be 383 short tons of metallic tin, valued at $360,000.

Some of the Alaskan gold ores carry considerable galena, and from this source some lead has been recovered. The total output of lead in Alaska since 1892, when the galena-bearing ores were first systematically mined, is estimated to be about 800 short tons, valued at $57,000.

Alaska's auriferous lodes are estimated to have produced during the year 232,916 fine ounces of gold, valued at $4,814,813, compared with an output of 241,991 fine ounces, valued at $5,002,399, in 1912. There was, however, a great advancement in lode development near Juneau and Fairbanks and much prospecting in various other districts.

Thirty gold-lode mines, including several properties in the new lode districts, which made only small outputs, were operated the whole or a part of the year 1913 in Alaska—six more than in 1912. Work was also done on many gold prospects. Of the producing mines 14 were in the Fairbanks district, 7 in southeastern Alaska, 3 in the Willow Creek district, 2 at Valdez, 2 in Kenai Peninsula, and 2 in southwestern Alaska. It is estimated that these mines had an output of 1,614,506 tons of ore, compared with 1,761,814 tons in 1912. In 1912 the average value of the gold and silver contents for all the ores mined was $2.85 a ton; the average for 1913 was $2.99.

There were seven productive copper mines in 1913, as compared with eight in 1912. Of these, three were in the Ketchikan district, three on Prince William Sound, and one in the Kotsina-Chitina district. The total production of copper in 1913 was 21,659,958 pounds, valued at $3,357,283, compared with 29,230,491 pounds, valued at $4,823,031, in 1912. About $132,000 worth of gold and $165,000 worth of silver was recovered from the copper ores. It is estimated that in 1913 about 135,736 short tons of copper ore was hoisted, compared with 93,452 tons in 1912. The average copper content of the ore was about 7.95 per cent, and the value of the gold and silver in the ore about $2.17 to the ton.

The value of the placer gold produced in 1913 is estimated at $10,600,000; that of 1912 was $11,990,000. The decrease is to be accounted for in large measure by the shortage of water. At Fairbanks, in the Innoko-Iditarod region, and on Seward Peninsula the sluicing season was probably less than half of the normal length. The total decrease in the value of the placer-gold production from these three most important regions is estimated to have been over $2,250,000. On the other hand, the value of the gold output from the Ruby district in 1913 was more than $500,000 greater in 1913 than in 1912. The other Alaskan camps yielded about the same in 1913 as in 1912.

It is estimated that a total of about 700 placer mines were operated in 1913, but many of them for only part of the season, compared with 720 in 1912. About 150 mines were operated during the winter, employing probably 800 men, and 650 in summer, employing about 4,500 men. In addition to this, some 1,500 to 2,000 men were engaged in prospecting and other nonproductive work relating to placer mining.

In accordance with past practice, a table is given here to show approximately the total bulk of gravel mined annually in Alaska for several years and the value of the gold recovered per cubic yard. This table is based on certain assumptions which do not now admit of proof but which are supported by a large number of facts. Therefore, although the table is only approximately correct, it indicates the magnitude of the true figures.

Estimated total amount of gravel sluiced in Alaska placer mines and value per cubic yard of gold recovered, 1908–1912.

	Total quantity of gravel.	Value of gold recovered per cubic yard.
	Cubic yards.	
1908	4,275,000	$3.74
1909	4,418,000	3.66
1910	4,036,000	2.97
1911	5,790,000	2.17
1912	7,050,000	1.70
1913	6,800,000	1.57

In some of the districts there was not even water enough for the dredges. As a consequence there were only 35 gold dredges operated in 1913, compared with 38 in 1912. It is estimated that these dredges handled about 4,100,000 cubic yards of material and made a gold recovery to the value of about $2,200,000, which is the same as the Alaska gold-dredge production of 1912. There were also six or eight dredges which, for one reason or another, were not operated in 1913, and a number of others are under construction or planned.

The discovery of auriferous gravels in the upper Matanuska region and in the upper basin of the Chisana, already noted, furnishes new fields for the prospector. These discoveries curtailed the gold output in some of the larger camps, because they drew away many miners, and thus caused a shortage of labor.

The dredging of placer tin in the York district, in the western part of Seward Peninsula, was continued during 1913. Work was also carried on at the lode-tin mine on Lost River, in the same district. Here a small concentration mill was erected and some concentrates were shipped. It is reported that there was considerable prospecting for lode tin at Ear Mountain, in the north-central part of the peninsula. A little placer tin which occurs with the auriferous gravels of the Hot Springs district has been mined. It is reported that in 1913 lode tin was found in this region.

REVIEW BY DISTRICTS.[1]

SOUTHEASTERN ALASKA.

Seven lode-gold mines, about four placer-gold mines, and three copper mines were operated on a productive basis in southeastern Alaska during 1913. Far more important was the extensive development of lode mines in the Juneau district and, to a lesser extent, in the Berners Bay region. The operating mines produced 201,360 ounces of gold, valued at $4,229,648; 29,211 ounces of silver, valued at $17,643; and 599,903 pounds of copper, valued at $92,985. A total of 1,589,746 tons of gold ore and 7,276 tons of copper ore was hoisted in 1913.

Juneau district.—The extensive mining developments, continued at Juneau during the year, bid fair to make it the center of one of the largest gold-producing districts on the continent. While in 1913 only the four mines of the Treadwell group were operated on a productive basis, a very large amount of development work was done on several other properties.

The ore of the Alaska Treadwell mine was taken chiefly from the 750, 1,250, 1,450, and 1,600 foot levels, but developments were made on the 2,100-foot level. The central shaft was sunk to a depth of 2,270 feet. At the Alaska-Mexican mine the ore came chiefly from the 1,100, 1,210, 1,320, and 1,460 foot levels. Most of the ore of the Ready Bullion mine was recovered from the 1,500, 1,650, 1,800, and 2,000 foot levels, and the most important dead work consisted of a shaft and the extension of the 2,200-foot level. The ore of the Seven Hundred Foot mine was taken chiefly from the 1,100, 1,210, and 1,320 foot levels; the dead work consisted of the sinking of a shaft and developments on the 1,450, 1,570, and 2,100 foot levels. Work was continued on the Nugget Creek power project.

The driving of the adit tunnel of the Alaska-Gastineau Co. was vigorously pushed throughout the year. Work was also continued on No. 1 shaft of the old Perseverance mine. These two workings

---

[1] Some of the districts are reviewed at greater length in later sections of this volume. In previous reports the review by districts was separated into sections on lode mining and placer mining. Here all the metalliferous deposits are discussed under each district.

were connected in April, 1914, thus giving an outlet, on one hand, to the surface at the Perseverance mine, and, on the other, to a point near sea level at Sheep Creek. The adit is 8 by 10 feet and 10,500 feet long. Meanwhile much development work has been done on the fifth to the tenth levels, inclusive, of the Perseverance mine, and mill construction and other surface improvements are well under way. One power plant on Salmon Creek for this enterprise is completed, and work on a second was continued during the year as weather conditions permitted.

The Snowslide Gulch adit of the Alaska-Juneau mine, 6,538 feet in length, was completed. A raise was then started which reached the surface in March, 1914. A working level was also started. A tram was built from the portal to the mill site near Juneau, where the first unit of a large reduction plant is approaching completion, and other surface improvements have been made. The company states that it plans later to put in a main adit tunnel from the mill site near Juneau, which will be 9,000 feet long and 400 feet lower than the present adit. Power is to be furnished from a hydroelectric plant on Nugget Creek.

Plans are under way to open the Ebner property, lying adjacent to the Alaska-Juneau on the north. This mine has been idle for some years but, it is said, will pass under a new management, with a promise of early development, as soon as certain legal complications have been settled. It is reported that some work has been done on a property lying north of the Ebner, which is said to be an extension of the stringer lead system in which the mines described above are located. So far as known the only other mining done near Juneau consisted of some placer operations in the upper Gold Creek basin.

Work was continued on the new adit tunnel of the Eagle River mine, located 800 feet below the old workings. This has been driven 1,900 feet and is reported to have intersected the ore body. Some developments were also made on the Peterson and Auk Bay properties. The driving of the adit of the Kensington mine, in the Berners Bay region, was continued. Two lodes, the Eureka and Kensington, had been crosscut by the adit, and in 1913 it was extended toward the Johnson lode, and this lode is said to have been crosscut 4,800 feet from the portal, at a depth of 800 feet. Some drifting on the lode was also done. It is reported that work was continued at the Jualin mine, consisting of the sinking of a shaft and surface improvements. Information is lacking at this writing regarding any other mining developments in the Berners Bay region. There is also no information at hand regarding mining operations in the southern part of the Juneau district.

Other districts.—Hydraulic plants were operated on Porcupine, Calhoun, and Nugget creeks in 1913. Another plant was installed on Glacier Creek, and preparations made for putting in a dredge on the lower part of Nugget Creek. Developments were continued in a small way on some quartz properties in this district.

The two 10-stamp mills of the Chichagof mine, formerly operated as two mines—the Chichagof and Golden Gate, in the Sitka district, were operated throughout the year. A new hydroelectric power plant and an air compressor are being installed and underground developments were continued. At the Hirst property, also in the Sitka district, the vein is reported to have been crosscut at the upper level, and another crosscut has been started 165 feet below this and 350 feet below the surface. About 1,250 feet of underground work has been done on this property.

The Jumbo and Rush & Brown copper mines, in the Ketchikan district, were operated on a shipping basis, and some developments were made on other copper properties, notably at the mines of the Northland Development Co., on the west side of Prince of Wales Island. The small stamp mills at the Valparaiso and Harris River gold mines were operated in 1913, and some developments were made on the Londevan and Bugge properties. The details in regard to mining in the Ketchikan district are presented elsewhere in this volume.

Mining was continued on the beach placers near Yakataga on about the same scale as in previous years. This district does not properly belong under southeastern Alaska, and as it is described at length in a later section of this report, it will only be mentioned here.

COPPER RIVER REGION.

Mining operations in the Copper River basin in 1913 included the development of copper mines in the Kotsina-Chitina belt, gold-placer mining in the Nizina, Bremner River, and Chistochina districts, and gold-lode prospecting at various localities.

Kotsina-Chitina district.—There was no great activity in the Kotsina-Chitina copper belt during 1913. With the present high freight rates on copper ore and in the absence of any spurs or branch lines of railways, operators found little encouragement to push development work. There was, moreover, a shortage of labor, due to the exodus to the Chisana placer district. The Kennecott-Bonanza continues to be the only productive mine, and its operation was hampered by the destruction of the tramway and compressor plant by a snowslide and fire. As a consequence, shipments were made for only about eight months during the year. Work was also continued on the Jumbo claims near by, belonging to the same company. Some small shipments of ore were made from this property, and the route for an aerial tram was surveyed. Some development work was done on the Dan Creek and other copper properties in the east end of the Kotsina-Chitina belt.

The Mother Lode mine is on the McCarthy Creek side of the Bonanza divide. Here the underground workings were extended during 1913, and a 6,600-foot aerial tram connecting the mine with a proposed wagon road following down McCarthy Creek valley was built. The wagon road has not been completed, but meanwhile some ore was sledded to the railway, a distance of about 13 miles. An air compressor, driven by a gasoline engine, is being installed. A gold quartz vein, located near McCarthy and belonging to the Bonanza Gold Mining Co., is reported by the owners to have been developed on a small scale. It is also stated that a small prospecting mill was installed on this property and that a small shipment of concentrates was made.

There was comparatively little mining at the west end of the field. Developments are reported on the Hubbard & Elliot property, on Nugget Creek, and on the Berg claim, on the east side of the Kuskulina River. Some work was also done by the Great Northern Development Co., which shipped ore from its property during the winter of 1912–13.

A small vein of quartz and calcite carrying considerable gold was found in the Kotsina region. As near as determined, this vein is located above timber line, some 4 miles north of Strelna station, on the south slope of the ridge separating Elliott Creek from Kotsina River. This discovery is not on Elliott Creek, as has been reported.

Nizina and Bremner districts.—In the Nizina placer district two large hydraulic plants were operated throughout the year and a third after it had been rebuilt. About 80 men were employed during the open season. In September, 1912, the hydraulic plant of the Dan Creek Mining Co. was almost totally destroyed by an unusually severe flood. The diversion dam and intake works were washed out. The entire pipe line, which followed the creek bottom, was either buried under gravel and débris or broken up and washed away, and the cut was filled from bank to bank. The flume and gold-saving apparatus were buried under about 15 feet of sand, gravel, and bowlders. In 1913 the plant was reconstructed and about 10 box lengths of the old cut cleaned out. The new pipe line follows along the left bank well above extreme high-water level and includes 6,400 feet of riveted steel pipe tapering from 30 down to 15 inches in diameter. It crosses Boulder Creek on a trestle 500 feet long at a maximum height of 36 feet. In connection with the pipe line about 600 feet of flume has been constructed and 150 feet of 5 by 7 foot tunnel driven through solid rock.

The Nizina Mining Co.'s plant on Chititu Creek was damaged by the flood of September, 1912, but not so severely as the plant on

Dan Creek. During the early summer the damaged section was reconstructed and the cut, which was partly filled with flood deposits, was cleaned out. Productive mining was carried on for the remainder of the season. The Nizina Mining Co. also operated an hydraulic plant on Rex Creek throughout the summer.

Five or six men were engaged in mining on Chititu Creek and its tributaries independent of the Nizina Mining Co. On Jolly Gulch and automatic dam was constructed.

Several years ago placer gold was discovered on a bench on the right side of Tiekel River, about 3 miles above the mouth. This ground has been prospected, and it is asserted that the gold content is sufficiently high to warrant the installation of a hydraulic plant. A winter road has been built from this property to the railway, and it is planned to haul hydraulic equipment over this roadway during the winter of 1914. There was also considerable gold-lode prospecting on the headwaters of Tiekel River.

The Budd Mining Co. commenced the installation of a hydraulic plant on Gold Creek, where it proposed to work gold placers in the basin above the lower falls. A timber dam 25 feet high and 100 feet long at the top and 212 feet of 3 by 6 foot flume were built early in the spring. On June 13, 1913, the dam was destroyed by high water and no further work was done during the season. Drill tests are said to show a gravel deposit 9 to 50 feet thick, with an average of about 25 feet.

Gold-lode prospecting.—The gold-bearing quartz of lower Copper River and the Lake McKinley region continues to attract prospectors, but no important developments have yet been made.

Chistochina district.—From 30 to 40 men were engaged in productive mining on nine or ten properties in the Chistochina placer district. A small hydraulic plant was installed and some ground was prospected with a view to the installation of a dredge.

PRINCE WILLIAM SOUND.

The value of the total mineral production of the Prince William Sound region in 1913 was $1,327,950, compared with $1,250,000 in 1912. The Ellamar and Beatson copper mines were operated to their full capacity, and shipments were also made from the properties of the Fidalgo Mining Co. and the Fidalgo-Alaska Copper Co. The Dickey Copper Co. opened the Mason & Gleason claim, on Fidalgo Bay, and mined some ore which will be sledded to the beach during the winter. Developments were continued by the Three Man Mining Co. and the Land Lock Bay Copper Co. Work was suspended during the summer at the Midas copper mine, near Valdez, but was resumed by a new company which purchased the property in the fall.

The Cliff mine, in the Port Valdez district, was operated throughout the year, and small mills were erected at the Gold King, Cameron & Johnson, Mountain King, and Minnie properties. Work was also done on about 25 other claims. It is estimated that about 200 men were engaged during 1913 in mining and development work in the Port Valdez district. There was considerable prospecting of auriferous quartz veins in the Port Wells district, and it is estimated that some work was done on about a hundred different claims. The mining developments on Prince William Sound are described in some detail in later sections of this volume.

KENAI PENINSULA.

In the aggregate there was considerable gold-lode prospecting in Kenai Peninsula during the year, but no important developments. Placer mining was continued on about the same scale as in previous years. The total value of the gold produced in the peninsula in 1913 was less than $50,000. At the Kenai-Alaska Gold Co.'s mine about 400 feet of crosscuts were driven and 150 feet of drifts along fissures. The aerial tram that was broken last year was repaired and the mill was run for a short time.

Work was continued at the Skeen-Lechner mine. A 4-stamp mill was completed in September and operated for the later part of the year by hydroelectric power. An aerial tram connects the mine with the mill. There was also much underground work, aggregating at the close of the year some 1,000 feet in length. On the property of the Primrose Mining Co. a 150-foot crosscut and a 30-foot raise were opened. A small prospecting mill was used for testing the ore, and a larger mill has been planned.

Late in the summer the Gold Stamp Mining Co. installed a 2-battery mill of five stamps near its claim on Bear Creek. Water power is to be utilized for this plant. Unfortunately, operations were suspended in October, owing to a lawsuit.

Development work was continued on the Gilpatrick lode, in the Moose Pass district. Some ore from this claim was treated in an arrastre. The Moose Pass Mining Co. continued operations in a small way on its claim, located near the head of Quartz Creek, and installed a small prospecting mill during the summer. Assessment work was done and some developments were made on the Bluebell, Sevenmile, Kenai Star, Tenderfoot, and other quartz claims.

About 15 placer mines, employing 40 to 50 men, were operated for a whole or a part of the open season of 1913. Operations were more or less hampered on some creeks by a scarcity of water. Most of these operations were on a very small scale, but hydraulic plants were operated on Resurrection, Bear, and Crow creeks. The testing of dredging ground on Kenai River and elsewhere was continued.

SOUTHWESTERN ALASKA.

Kodiak Island.—The Aniak Gold Mining Co., whose property is near Uyak, on Kodiak Island, continued work on its property. It is reported that 115 feet of shaft was sunk and 77 feet of drifts opened. The stamp mill was operated to test the ore. There was also some mining of beach-placer gold on Kodiak Island, as well as prospecting of gold-lode deposits.

Iliamna region.—The following notes on the Iliamna region are based chiefly on information furnished by Mr. Thomas W. Hanmore, United States commissioner at Iliamna. With the exception of the recovery of a few hundred dollars' worth of gold from the gravels of Portage Creek, a tributary of Lake Clark, there was no productive mining in the Iliamna region. There was, however, considerable prospecting and development of copper and gold bearing lodes in this region.

The McNeil-Cook group of claims is located about 17 miles from tidewater at Kamishak Bay, an indentation of the southwest shore of Cook Inlet. The ore is chalcopyrite, said to carry considerable gold and to occur in well-defined leads. The developments consist of open cuts and one adit 23 feet in length. The description of the region suggests that the occurrence may lie in a southwesterly extension of the mineralized belt[1] lying between Iliamna Bay and Iliamna Lake.

Nothing was done on the Dutton copper property in 1913 except some sampling. Work was continued in a small way on the Duryea claims, on claims near Kontrashibuna Lake, on the Millet claims, near Iliamna Lake, and on the Gleason claims, near Lake Clark. A few men are still prospecting in the Mulchatna placer district.

Alaska Peninsula.—So far as known there was little mining development on the Alaska Peninsula in 1913. No report has been received from the Apollo mine, but it is rumored that the mill was run for a short time and that some underground work was done.

SUSITNA AND MATANUSKA BASINS.

Albert Creek placers.—During the summer of 1913 considerable local excitement was caused by the discovery of auriferous gravels in the region adjacent to the upper Matanuska basin. As a consequence, 75 to 100 prospectors were attracted to this region. Placer gold was found on Albert Creek, a branch of Crooked Creek, tributary to Nelchina River. The Nelchina is one of the forks of the Tazlina, which joins Copper River from the west about 8 miles above Copper Center. This region is described in a later section of this volume.

---

[1] Martin, G. C., and Katz, F. J., A geologic reconnaissance of the Iliamna region: U. S. Geol. Survey Bull. 485, p. 138, 1912.

Willow Creek district.—Mining in the Willow Creek lode district continued on about the same scale as last year. Three mills—the Gold Bullion, Alaska Free Gold, and Gold Quartz—were in more or less continuous operation, and about 70 men were employed in mining and milling. About 3,000 tons of ore was milled, with a gold recovery to the value of $100,000. Several promising discoveries of quartz veins were made during the year, and plans were under way to install mills at three additional localities next spring. A somewhat detailed account of the Willow Creek district is contained in a later section of this report.

Yentna district.—Placer mining in the Yentna district was continued in 1913 on about the same scale as during the last few years. No important new discoveries were made and the production was all obtained from creeks whose value had already been proved. In several localities preparations for more extensive mining by hydraulic methods had been made, but an unusual scarcity of water through practically the whole working season affected all the properties, and several claims which for a number of years have been profitably operated yielded little or nothing this year. The shortage of water in the summer of 1913 is attributed to an unusually light snowfall during the preceding winter, the snow banks which ordinarily supply the streams throughout the open season having this year disappeared early in the spring. No member of the Geological Survey visited the Yentna district in 1913, and the information here given was supplied by a number of miners who were seen after the close of the mining season by S. R. Capps.

As usual, Cache and Peters creeks and their tributaries furnished most of the gold production. On Cache Creek proper the Cache Creek Mining Co. worked on a low bar just above the sawmill, and it is reported that the ground mined yielded satisfactory returns. Hydraulic methods were used, the water being obtained from Rambler Creek.

On upper Cache Creek only a small amount of the creek gravels was mined. An attempt was made to establish the value of some higher bench deposits near the canyon, but the results of this prospecting are said to have been unsatisfactory. Prospecting was continued on lower Cache Creek below the lower canyon, and the existence there of extensive unfrozen gravel deposits suitable for dredging is reported.

Preparations were made for active mining on Gold Creek. A ditch half a mile long, to obtain water under pressure, was completed, and some ground sluicing was done, but the failure of the water supply prevented the owners from cleaning up the cut, and no production was made. Mining operations were conducted at four localities on

Nugget Creek. At a point a short distance below the canyon, on the south side of the creek, several men were employed in exploiting the elevated bench gravels. These benches have been shown to carry considerable gold, and some unusually rich spots are said to have been discovered. Several men were engaged in prospecting the high bench ground north of the canyon. A ditch 2 miles long supplied water under pressure, and many cuts were made in the attempt to locate a valuable placer. It is reported that the results were encouraging. Two men were mining on lower Nugget Creek and had ground-sluiced a considerable area when a freshet washed out their boxes and filled the cut with gravel.

The Thunder Creek Mining Co. continued mining on lower Thunder Creek and is said to have employed eight to ten men continuously. There was also one other mining venture on upper Thunder Creek. Mining was conducted on Falls Creek at only one locality.

One of the most important mines of the district, operating on an old channel in the valley of Dollar Creek, was this year unfortunately involved in litigation, so that little work was accomplished. An adequate place to dump tailings was lacking, and operations were confined to cleaning up a portion of the cut made in 1912. Near this mine the Conhardt Mining Co. was also operating, employing from six to ten men.

In the main valley of Peters Creek mining was conducted near the mouth of the lower canyon at two places. One outfit, said to have operated on the benches above the mouth of the canyon, was compelled to discontinue work in June on account of the scarcity of water. A short distance below the mouth of the canyon another company built a dam across Peters Creek and is said to have opened some rich placer ground. A freshet, however, washed out the dam and prevented further mining after a small amount of gold had been recovered.

Willow and Poorman creeks, in the Peters Creek basin, were both mined in the early summer, but operations were discontinued in mid season because of lack of water. It is said that low water also put a stop to work on Bird Creek during most of the season.

Little is known of the results of the season's mining in the tributaries of Mills and Twin creeks, but it is reported that the streams were so low that practically nothing was accomplished.

To summarize, the best information obtainable indicates that under average conditions of stream flow the gold output of the Yentna district in 1913 would have been considerably above the average for the last five years. As a result of a shortage of water and of a lawsuit which restricted the operations of one important mine, the output for the season of 1913 was less than that of 1912.

Valdez Creek district.—The most important development during the year on Valdez Creek, a tributary of the upper Susitna, was the installation of a large hydraulic plant for the recovery of gold in a buried channel. This plant was completed before the close of the summer, and some sluicing was done. There were also some smaller operations on Valdez Creek and its tributaries. These operations are described elsewhere in this volume.

YUKON BASIN.

The dry weather and other conditions already discussed gave the Yukon districts very unfavorable conditions for placer mining. The value of the placer production is estimated to be about $7,780,000 in 1913, compared with $8,645,000 in 1912. The newly discovered Chisana placer-gold district, in the upper Tanana Valley, was encouraging to the prospector but caused a movement of miners that resulted in a shortage of labor in several camps. On the other hand, the progress in lode mining at Fairbanks is a very hopeful feature of the year's history. Most of the Yukon districts are described in some detail in other parts of this volume, so that only a summary statement will be given here.

Chisana district.—In May, 1913, William E. James and Peter Nelson found gold placers on a small stream, called by them Little Eldorado, which flows into Bonanza Creek, tributary to Chatenda or Johnson Creek. Chatenda Creek is an easterly fork of the upper Chisana River, locally called the Shushana. During the summer mining was done on Discovery claim and on some other claims in the neighborhood. The value of the total output from the district is variously estimated between $30,000 and $70,000. Gold has also been found on several tributaries of Chapolda or Wilson Creek, which lies across the divide north of Johnson Creek and flows westward into the Chisana. This district is a part of the Nabesna-White River region, where some copper prospects are being developed. It is described in greater detail elsewhere in this volume.

Fairbanks district.—During 1913 quartz mining made steady progress in the Fairbanks district. There were 13 lode properties that produced more or less, and 10 of them were equipped with mills. Gold to the value of $350,000 was produced from the quartz mines of the district in 1913 and $200,000 in 1912. This makes the total production from the gold lodes of the district about $674,000—a remarkable showing considering the handicap under which the lode mines are placed by the high cost of fuel, labor, and supplies.

About 130 placer mines were operated in the Fairbanks district for a whole or a part of the year. These gave employment to about 700 men in winter and 1,800 in summer. The value of the placer gold produced was about $3,300,000. The chief creeks named, in the order of the value of their production, were Chatanika Flats and Cleary, Ester and tributaries, Goldstream and Engineer, Dome, Pedro, Fairbanks, and Little Eldorado. Gold was also mined on Vault, Treasure, Wildcat, Fish, and Happy creeks. Some new discoveries were made on Alder, Smallwood, and Happy creeks, and the productive area in the Chatanika Flats, at the mouths of Dome and Cleary creeks, was enlarged. New mines were also opened on Fairbanks and Dome creeks. Mining in Fairbanks district is described at greater detail elsewhere in this volume.

Smaller Yukon districts.—Twenty mines, including two hydraulic plants, were worked for a whole or a part of the season in the Birch Creek district. One dredge was operated on Mastodon Creek. About 130 men were employed during the summer, and there was considerable winter work, but shortage of water prevented the sluicing of the dumps. Mastodon, Eagle, and Half Dollar creeks were the principal producers.

In the Fortymile region the shortage of water greatly hampered mining operations. About 25 mines were worked in the winter and 15 in the summer. One dredge was operated on south fork of Fortymile Creek. Operations were continued on about the same scale as in the past in the Eagle, Seventymile, Rampart, Kantishna, Tenderfoot, and Bonnifield districts. The Hot Springs district continues to be one of the large producers of gold in the Yukon region, chiefly from Sullivan, Patterson, and American creeks.

Ruby district.—All told 41 plants were engaged in mining in the Ruby district, operating 38 claims on 14 creeks and employing a total of about 230 men. The most significant new development in the district was the discovery of valuable placer ground on several creeks in an area about 30 miles south of the Long Creek locality. The chief discoveries are on Poorman Creek, tributary to the North Fork of Innoko River, and on Duncan and Tenderfoot creeks, tributary to Poorman Creek from the north. Pay gravel has been struck also on Tamarack Creek, a tributary of the Solatna that heads against Duncan Creek. Good prospects are reported from Spruce Creek, a tributary of the Solatna west of Tamarack Creek, heading in Twin Butte Mountain. The Ruby district is described elsewhere in this volume.

Chandalar and Koyukuk districts.—The owners report that work was continued on the Little Squaw quartz property, in the Chandalar district, that the adit on the vein was driven about 100 feet, making a total distance from the portal of 178 feet, and that a winze was sunk about 50 feet. This makes a total depth below the outcrop of about 100 feet. The ore recovered in mining was hauled to the 3-stamp prospecting mill and there treated. On the Carter property, in the same district, a crosscut has been driven for 400 feet and is said to have intersected the ore 200 feet below the surface. A little placer mining was done on two claims in the Chandalar district.

Reports from the Koyukuk district are very meager, as but few of the mine operators there return the schedules mailed to them each year. Nor has the writer been able, as he has in nearly all the other Alaska mining districts, to find anyone who is willing to furnish the Survey with any information on mining development. It is therefore impossible to do justice to this important camp in the annual reports on the mining industry of Alaska.

From best reports, between 300 and 400 men were engaged in placer mining on the Koyukuk in 1913, and the season was a profitable one, although there was some shortage of water, as in the other Yukon camps. The most important developments were those on Hammond River, where some deep rich gravels were developed. A little mining was done in the Indian River district of the middle Koyukuk basin. Here 13 claims were worked in a small way. The Indian River region is described in a later section of this report.

Iditarod district.—As in the other Yukon camps, the shortage of water greatly hampered mining operations in the Iditarod district. This condition, together with the fact that certain claims were not worked because they were being combined for the purpose of exploiting them in a large way, led to a great curtailment of gold output compared with the previous year. The value of the gold produced in the Iditarod district was about $1,860,000. There was some prospecting of lode claims and some promising deposits have been found, but the cost of mining is so great that few have been attracted to quartz development.

The dredge installed on Flat Creek in 1912 was worked throughout the open season. A second large dredge was built on Flat Creek in 1913, and also operated. Preparations have been made for the installation of a dredge on Otter Creek, which it is expected will be completed for operating in 1914, and also one on Moore Creek, a tributary of the Kuskokwim.

The largest part of the gold produced in the Iditarod district came from the mines on Otter and Flat creeks, but mining was also done on Happy, Willow, Moore, Chicken, and Black creeks and Glenn Gulch. Most of the mining is done in open cuts, steam scrapers being extensively used.

Innoko district.—Shortage of water curtailed the Innoko gold output in 1913, estimated to have a value of $280,000, of which about $80,000 worth was mined in the winter. Sixteen claims were worked in the winter, employing about 50 men, and 28 in summer, employing about 125 men.

The most important developments were on Little Creek, where a considerable area of rich placer was found. The productive creeks, named in the order of the value of their production, were Little, Ophir, Spruce, Colorado, Fox, Ganes, and Yankee. Some claims on Yankee Creek have been combined for the purpose of mining by dredge. Dredging ground was also prospected on Ganes Creek, with reported favorable results.

There was some extensive prospecting of Candle Creek, which flows into the Tokotna, a tributary of the Kuskokwim. Mr. Harold Seddon reports that the country rock is granite, and that the gravels are 9 to 12 feet deep, near the head of the creek, and increase in thickness rapidly downstream. About a mile from the head of the creek the gravels are 25 feet deep, and about half a mile farther down they are 56 feet deep. Two miles still farther downstream shafts sunk to 125 feet have failed to reach bedrock and were abandoned on account of water. The upper creek was prospected with bedrock drain and the claims below by shafts and drilling, and the returns are said to be satisfactory. There was a considerable inrush of prospectors in the region lying between the Innoko and Ruby districts. The scene of new discoveries is in part in the Innoko basin but belongs to the Ruby district and has been referred to on page 68. It is described at greater length in another article included in this volume.

KUSKOKWIM BASIN.

In the lower half of the Kuskokwim basin there are many creeks on which some mining has been done, but about which there is very little information. It is planned in 1914 to investigate a part of this region, but meanwhile the writer is forced to rely on information gleaned from various sources. What is known of the mining developments in that part of the basin included in the Iditarod and Innoko districts has been already presented. There is a mineralized area lying south of the lowest big bend of Kuskokwim River and draining in part to the north through Anniak River, which joins the Kuskokwim from the south about 25 miles below Kolmakof and in part to the northwest through Tuluksak River, tributary to the Kuskokwim from the east about 30 miles above Bethel. Within this area considerable gold-bearing gravel has been found and mining has been going on for several years. In 1913 a hydraulic plant was in the course of installation on Marvel Creek, in the Anniak basin. There has been some mining on Marvel, Cripple, and other creeks of the Anniak district.

Across the divide is Bear Creek, a tributary of the Tuluksak, and here mining has gone on for several years. Gold is said to be [illegible] tributed throughout the length of the creek. In 1913 considerable ground was prospected on Bear Creek with a drill, and preparations were made for the installation of a steam scraper. Mining has also been done on Bonanza Creek, a tributary of Bear Creek.

Eek River flows into the Kuskokwim from the east about 50 miles below Bethel. In 1913 placer gold was found in the headwater region of the Eek, indicating that the region between the Tuluksak and Goodnews Bay districts is also mineralized. About a dozen men were engaged in mining and prospecting in the Goodnews Bay region. The gravels are said to be of low tenor, but good dredging ground is reported. A little mining was done during 1913 on Butte, Snow Gulch, and Kowkow creeks, in this district, but as a rule the values are too low to permit profitable recovery with the crude methods now in use.

SEWARD PENINSULA.

The drought which prevailed all over northern Alaska was especially pronounced in Seward Peninsula. So low were the streams that even some of the dredges could not operate, and for others it was necessary to make artificial basins by cutting into the bedrock or by building dams. As a result the gold recovery of 1913 in the Seward Peninsula camps was only $2,500,000, compared with $3,100,000 in 1912.

Thirty-one dredges were operated for a part or the whole of the summer, with an estimated gold recovery of $1,300,000. These dredges had a combined daily capacity of 33,300 cubic yards. Four new dredges were installed in 1913, and several others were in course of construction. The building of several others is under contemplation. In addition to the 31 operated, there were six dredges that were idle in 1913. Of other than dredge mining there was very little. Some deep mining was done during the winter near Nome and in the Fairhaven district. In some places there was not water enough in the summer to sluice the winter dumps. A little hydraulic mining was done in several districts when the water supply permitted. The dry season also hampered the small operators throughout the peninsula. There was some development of auriferous lodes in Seward Peninsula, but no production.

The dredge used for mining placer tin in the York district was operated throughout the open season. There was also a large amount of development work done on the tin-bearing lode at Lost River, where a small concentrating mill was installed. Details about mining in Seward Peninsula are presented in separate papers included in this volume.

KOBUK REGION.

The placer mines of the Kobuk region produced about $40,000 worth of gold in 1913. Most of this came from Klery Creek, in the Squirrel River district, but there was also a little mining on Lynx and Dahl creeks and on Shungnak River. Some work was done on the Malfiatti copper claim, in the Hunt River valley, and the results are said to be satisfactory. The remoteness of the Kobuk region makes all forms of mining very expensive and has discouraged prospecting.

MINERAL FUELS.

As no patents have been granted to coal lands and no leasing law has been passed, Alaskan coal fields still continue undeveloped. The only exception is the Wharf mine, on Port Graham, located on about 65 acres of coal land, to which patent was granted in 1913. This mine has been opened and its coal, which is lignitic, has found a local market. There has also been a little mining of lignitic coal for individual use at various other localities in Alaska. The following table shows the coal consumption of Alaska from 1899 to 1913:

Coal consumption of Alaska, by sources, 1899 to 1913, in short tons.

Year.	Imported from States, chiefly from Washington.		Produced in Alaska, chiefly subbituminous and lignite.[a]	Total domestic, chiefly from Washington.[a]	Total foreign coal, chiefly bituminous, from British Columbia.[b]	Total coal consumed.
	Bituminous.	Anthracite.				
1899	[c] 10,000	....	[c] 1,200	11,200	50,120	61,320
1900	15,048	....	[c] 1,200	16,248	56,623	72,871
1901	[c] 24,000	....	[c] 1,300	25,300	77,674	102,974
1902	[c] 40,000	....	2,212	42,212	68,363	110,575
1903	64,625	1	1,447	66,073	60,605	126,678
1904	36,689	....	1,694	38,383	76,815	115,198
1905	67,707	6	3,774	71,487	72,567	144,054
1906	68,960	533	5,541	75,034	47,590	122,624
1907	45,130	1,116	10,139	56,385	88,596	144,981
1908	23,402	491	3,107	27,000	72,831	99,831
1909	33,112	....	2,800	35,912	74,316	110,228
1910	32,138	....	1,000	33,138	73,904	107,042
1911	32,255	....	900	33,155	88,573	121,728
1912	27,767	....	355	28,122	59,804	87,926
1913	61,666	....	[c] 2,300	63,966	60,600	124,566
	582,499	2,147	38,969	623,615	1,028,981	1,652,596

[a] By calendar years. [b] By fiscal years ending June 30. [c] Estimated.

The writer is indebted to Mr. Charles Estmere for notes on an occurrence of coal in the Iditarod district. The locality of this occurrence is about 4 miles from Iditarod, near the Flat Creek tramway. Mr. Estmere reports that the coal bed strikes about N. 60° E. and dips about 50° S. It has been opened by an incline to a depth of about 50 feet below the outcrop. The bed is reported to vary from 15 to 30 inches in thickness and to have a shale roof and slate floor. There is evidence of considerable shearing along the footwall.

A sample of this coal was received from Mr. Estmere and analyzed by A. C. Fieldner, chemist of the Bureau of Mines, with the following results:

Analysis of coal from locality near Iditarod.

[Air-dry loss, 0.0.]

	Air dried.	As received.	Moisture free.	Moisture and ash free.
Moisture	1.40	1.42		
Volatile matter	6.60	6.60	6.70	7.23
Fixed carbon	84.75	84.73	85.95	92.77
Ash	7.25	7.25	7.35	
	100.00	100.00	100.00	100.00
Sulphur	1.10	1.10	1.12	1.21

This analysis indicates that the coal is anthracite. The sample received was chiefly slack, and the data at hand indicate that the coal bed is crushed. It is doubtful whether this coal could be utilized without briquetting. Its high grade and close proximity to a good market justify further expenditures in prospecting.

About 600 tons of coal was mined on one of the Cunningham claims, in the Bering River field, in 1912. This operation was conducted under a special appropriation made to the Navy Department but was under the supervision of the Bureau of Mines. The coal was taken from two beds in the bituminous part of the field. It was brought to the coast in the summer of 1913 and given official tests on a warship, and also at Annapolis. These tests show that the coal mined will not yield a fuel suitable for Navy use. The complete report has not been published at this writing.

In 1913 a similar test of Matanuska coal was undertaken. About 1,100 tons of coal was mined at Chickaloon during the summer, and this was sledded to the coast at Knik during the winter of 1913–14. This coal is to be subjected to a steaming test, as was the coal from the Bering River field.

The Alaskan oil lands were withdrawn from entry in 1906, and only those claims located previous to that date are subject to entry. Patents have been granted to a few claims in the Katalla oil field, near Controller Bay, and some of these have been placed on a productive basis. No development work has been done in any other oil field since the withdrawal.

The moderate production of petroleum at the well-known seepage locality near Katalla was continued during 1913. A small experimental refinery installed there several years ago for the manufacture of gasoline was somewhat improved in 1913. By cleaning several of the old shallow wells 600 to 700 feet deep and by drilling one or two new holes [illegible] of 800 to 1,000 feet the daily pumping capacity [illegible] increased to about 60 barrels of crude [illegible] be about the limit in depth [illegible] the area now producing.

The oil thus obtained appears to be a more or less superficial and localized accumulation stored in much-shattered shales whose relation to deeper or more extensive sources is not known. In all there are about 10 of these relatively shallow wells on the property whose possible yield varies from 2 to 10 barrels a day. However, these are not all being steadily pumped. The gasoline is sold in a limited market about Prince William Sound, and as the demand of this market varies, the refinery is not operated at a uniform rate of production. In quality the gasoline is fully as good as that brought from the United States.

While the coal consumption in Alaska has remained nearly stationary, the use of fuel oil has very much increased. The Treadwell group of mines now uses California oil, as do many of the dredges at Nome, steamers running to Alaska, and the Yukon River boats. The Copper River Railway is now in part equipped with oil-burning locomotives, and the Alaska Northern Railway, when operated at all, uses a gasoline car. The Tanana Valley Railway also runs a gasoline passenger coach. The following table indicates the increased use of oil-burning and gasoline engines in Alaska:

Shipments of petroleum products to Alaska from other parts of the United States, 1905-1913, in gallons.

Year.	Crude.		Naphtha.		Illuminating.		Lubricating.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1905..	2,715,380	$91,068	713,496	$109,921	627,391	$113,921	83,319	$31,660
1906..	2,688,100	38,409	580,978	100,094	568,033	109,964	83,992	32,854
1907..	9,104,300	143,506	636,881	119,345	510,145	99,342	100,145	37,929
1908..	11,891,375	176,483	939,424	147,104	566,598	102,567	94,542	36,423
1909..	14,034,900	334,258	746,930	118,810	531,727	98,786	85,687	35,882
1910..	18,835,670	477,673	788,154	136,569	626,972	95,483	104,512	38,625
1911..	18,142,364	406,400	1,238,865	167,915	423,750	57,896	100,141	34,048
1912..	15,523,555	309,804	2,736,739	344,739	672,176	100,722	154,565	60,949
1913..	15,682,412	453,756	1,735,658	272,661	661,656	106,603	150,918	61,966

STRUCTURAL MATERIAL AND MISCELLANEOUS.

There were no important developments in the marble or gypsum industry of Alaska in 1913. While marble is widely distributed in southeastern Alaska,[1] the only locality of production in 1913 was on Marble Island, near Shakan. Here quarrying is done on a large scale. Some development work was done on marble deposits at a number of different localities in southeastern Alaska.

The only gypsum deposit thus far found in the Territory is on Chichagof Island, in the Sitka district. The shipping facilities of the plant, which is close to tidewater, were improved in 1913.

Some volcanic tuff (ash) was shipped from Kodiak in 1913 for use as an abrasive. This was derived from the débris resulting from the eruption of Mount Katmai in June, 1912.

---

[1] Some of the marble deposits of southeastern Alaska are described in a later section of this volume.

LODE MINING IN THE KETCHIKAN REGION.

By Philip S. Smith.

INTRODUCTION.

During the investigation of the stratigraphy of part of the Ketchikan region from May 15 to July 26, 1913, almost all the mines and important prospects of gold and copper were visited. The data then acquired form the basis for this report on the conditions of mining in 1913. Detailed descriptions of many of the mines have been given in previous reports of the Survey and have not been repeated here. For a complete description of the earlier mining activities in the Ketchikan region the reports by the Wrights, Paige, and Knopf should be consulted.[1]

MINING CONDITIONS.

Lode mining in the Ketchikan region was not active in 1913. Three copper and three gold mines were in more or less continuous operation and about a score of prospects, most of which have been known for several years, were further developed. The value of the total production from all the mines and prospects for the year was less than $200,000. This production, though considerable in the aggregate, passes into the hands of a few operators, so that the community as a whole has less interest in mining than in the enterprises associated with the fishing industry, in which the profits are more widely distributed.

---

[1] Wright, F. E. and C. W., Lode mining in southeastern Alaska: U. S. Geol. Survey Bull. 284, pp. 30–53, 1906.

Wright, C. W., Lode mining in southeastern Alaska: U. S. Geol. Survey Bull. 314, pp. 47–72, 1907.

Wright, C. W., and Paige, Sidney, Copper deposits on Kasaan Peninsula, Prince of Wales Island: U. S. Geol. Survey Bull. 345, pp. 98–115, 1908.

Wright, C. W., Lode mining in southeastern Alaska: U. S. Geol. Survey Bull. 345, pp. 78–97, 1908.

Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, 1908.

Wright, C. W., Mining in southeastern Alaska: U. S. Geol. Survey Bull. 379, pp. 67–86, 1909.

Knopf, Adolph, Mining in southeastern Alaska: U. S. Geol. Survey Bull. 442, pp. 133–143, 1910.

Knopf, Adolph, Mining in southeastern Alaska: U. S. Geol. Survey Bull. 480, pp. 94–102, 1911.

Wright, C. W., Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska: U. S. Geol. Survey Prof. Paper 87 (in press).

The waning interest in mining is due not to the absence of mineralization but rather to the lack of adequate capital and intelligent management for the prosecution of development. To judge from the area examined by the writer last summer there are probably many small lodes of high tenor. The future mining activities in the region, however, depend not so much on these lodes as on large deposits of low-grade material. In this region of strong relief, where water transportation by ocean-going vessels is readily accessible and where labor and supplies are little more costly than in Seattle or San Francisco, the expense of mining can be made very low. The attainment of cheap mining, however, requires careful selection of the area to be mined, considerable original outlay of capital, and a skillful management versed in the most efficient of modern mining practices. Unfortunately the mines that have been opened in the Ketchikan region have seldom if ever had the advantage of this desirable combination. With the failure that has inevitably resulted from the lack of one or more of these requirements, confidence is shaken and the region as a whole receives a setback which makes the development of its mining industry increasingly difficult.

MINES AND PROSPECTS.

DISTRIBUTION.

Most of the mineralization occurs in those regions where sedimentary rocks are intruded by igneous rocks, and almost all the mines and prospects lie in these areas. So widespread are these conditions, however, that few places in the Ketchikan region are more than a short distance from some igneous contact. As a consequence, until further study determines the other factors which are necessary to produce workable ore deposits. almost all the Ketchikan region warrants critical examination.

Although mineralization is widespread and may be found in nearly all the rocks of the region, it seems to be especially abundant in the belts of black graphitic quartzose slates and schists and in the vicinity of certain limestones. On the other hand, it is almost entirely absent from the larger masses of granitic rocks, except in a rather narrow marginal zone. The geologic mapping of the different terranes, therefore, should throw considerable light on the distribution of mineralization and should show the geologic relations of the known mineral deposits and indicate the places where similar conditions may prevail in undeveloped areas. Unfortunately investigations have not yet been carried far enough to give this information, and in this report the different mines and prospects are described by geographic localities. The three main mining areas are Prince of Wales Island, the mainland, and Revillagigedo Island. Mining work in each of these main areas will be described separately and the scattered prospects which do not fall into one of the above subdivisions will be described under the general heading "Miscellaneous localities."

On Prince of Wales Island the most active mining was done on Karta Bay, Kasaan Peninsula, near Port Johnson, and near the head of Hetta Inlet. At Big Harbor, on the west coast of the island, copper ore was produced, but the property was not visited by the writer. Some prospecting was in progress on these areas and also on Cholmondeley Sound, McLean Arm, Mallard Bay, and Brownson Bay. All these places except the last two were examined. On the mainland development has been in progress at only two places—at the head of Portland Canal near the international boundary (not visited by the writer) and on Cleveland Peninsula north of Ketchikan. On Revillagigedo Island the only active mining was done on George and Thorne arms, fiords a short distance southeast of Ketchikan.

PRINCE OF WALES ISLAND.

KASAAN BAY AND VICINITY.

Kasaan Peninsula, which several years ago was the scene of considerable copper mining, was practically deserted by miners throughout 1913. The only producing property was the Rush-Brown mine, about 2 miles inland from the head of Karta Bay. The development at this place has been rather fully described by Wright,[1] and the description will not be repeated here. Two main ore bodies, known locally as the magnetite and the sulphide bodies, have been extensively opened and another, known as the third ore body, has been slightly prospected. The ore occurs mainly in the form of chimneys whose longer axis is steeply inclined to the surface. It is mined mainly for its copper content, but it also carries considerable gold and so large an amount of iron that the smelters allow a premium for it. Numerous small slips intersect the ore bodies and in one or two localities have displaced the deposit several feet. Late basic dikes here and there cut the ore bodies, but have not been affected by faulting.

Fourteen men were employed on this property more or less continuously throughout the year. A new boiler and hoist were installed in 1913. The working shaft is 177 feet deep and the first level has been driven 187 feet and the second 177 feet. A winze has been sunk to open a third level. The ore is conveyed from the mine to the sea by a narrow-gage railroad about 2 miles long and is there loaded on ocean-going steamers.

---

[1] Wright, C. W., Geology and ore deposits of Copper Mountain and [illegible] Alaska: U. S. Geol. Survey Prof. Paper 87 (in press).

A report was circulated early in the season that certain copper properties east of the Rush-Brown mine had been examined, with a view to their purchase. No account of the results of this investigation has been received and presumably the terms were not satisfactory. The lack of mining in this region is not evidence that the deposits have been exhausted, for at several places the owners expect an early resumption of work.

Another mining center in the neighborhood of Kasaan Bay that used to be active is in the vicinity of Hollis, a settlement on Twelvemile Arm, the southern prolongation of Kasaan Bay. Only one property was in operation at the time of the writer's visit, the Rogers mine, on the claim formerly known as the Julia, on Harris Creek, about 2½ miles southwest of Hollis. Five men were employed more or less continuously on the property and in May were mainly engaged in equipping the 5-stamp mill which they expected to have in running order by June 1. The mine and mill are situated close to Harris Creek, a stream large enough to furnish water power to run the necessary machinery. Already part of this power has been utilized by means of a 6 by 8 foot flume, which delivers water to three turbines, of which two are capable of developing 38 horsepower, and the third 25 horsepower.

The lead that has been mined consists of numerous quartz stringers and veins in a black, somewhat graphitic, schistose slate. Both the schist and the vein strike in general N. 35° E. and dip northwest at fairly steep but variable angles. Near the surface the dip is approximately 45°, but lower down it flattens so much that in the length of the inclined shaft—205 feet—a vertical depth of only 95 feet is attained. The average dip from the top to the bottom of the shaft is therefore less than 28°. The width of the material mined ranges from 2 feet to more than 6 feet. This narrowing and swelling of the deposit takes place parallel both to the dip and to the strike.

The ore is mainly valuable for the gold it contains. Although no accurate determination of its value has been made by the writer, it is reported to carry gold in commercial quantities. Sulphides are scattered through both the quartz and the inclosing slates but do not form an appreciable portion of the rock. Pyrite is the most common sulphide, but some sphalerite, chalcopyrite, and galena were also recognized. The gold is said to be mainly native and is especially abundant near the contact of the quartz stringers and the country rock.

Only a small production has been made from this property in the past, but it should be materially increased when the mill is completed. Some ore has already been blocked out underground, but this development should be continued energetically, so that a sufficient reserve may be kept ahead of the mill. Some rock for milling can be obtained from the old dumps, for they are reported to assay nearly as high as the vein material underground and would therefore pay for reworking. No special difficulties in mining the deposit have so far been met. At the time of the writer's visit the lower part of the shaft and certain drifts were full of water, which had been collecting for several days, but the mine really is not wet. In fact, the operators report that two hours' pumping a day is sufficient to keep the mine dry.

No work has been done for several years at the Puyallup and Crackerjack mines, which lie northwest of Hollis. A small lot of ore was shipped from the Lucky Nell claim, formerly called Flora and Nellie, but no statement of the quality or tenor was obtained. A little prospecting has been done recently on the Commander group of claims, now known as the President 1 and 2, which lies east of the Lucky Nell claim and is about 6 miles northwest of Hollis, but no production has been reported. The old group of claims called the George group, which lies between Hollis and the Julia claim on Harris River, has been renamed the Hendy 1, 2, and 3. No work has been done at this place for several years, but the owners proposed to develop the claims during the later part of 1913, though the work had not been started at the time of the writer's visit. Undoubtedly some work is done annually on other claims in this region, but probably it seldom exceeds that required by law.

CHOLMONDELEY SOUND AND VICINITY.

No productive mining was in progress in the vicinity of Cholmondeley Sound in 1913, and the only places where prospecting was at all active were south of the head of Dora Bay and east of the head of Kitkun Bay. At neither place, however, were more than two or three men employed at a time, and these for only a part of the year.

The claims near Dora Bay are situated between Mineral Lake, which discharges into the north arm of Moira Sound, and Dora Lake, a tributary to Dora Bay. Three claims trending approximately north and one trending northwest have been staked in this region. These claims are, from south to north, the Portland, Seattle, and Portland No. 1; the transverse claim is the Clifton. The Clifton and Portland No. 1 overlap in part. The ore from all these claims is said to contain sphalerite, galena, and copper sulphides, but the last is the main source of value. In addition to these base metals all the ore is said to contain some gold. In certain specimens that were examined a considerable quantity of native gold was intimately associated with the sphalerite. From the relation of the sphalerite and gold to the quartz in which they both occurred the most reasonable explanation of their association is that an earlier series of quartz veins was later fractured and sulphides with gold from a deep-seated source were introduced.

The prospecting east of the head of Kitkun Bay was on the claims formerly known as the Crœsus group. The work at this place is said to have been mainly to fulfill assessment requirements but is reported to have disclosed some fairly good ore. The country rock is a highly contorted, rather massively laminated dark green schist closely associated with limestones. These claims were not visited by the writer.

PORT JOHNSON AND VICINITY.

Port Johnson is a small indentation on the east coast of Prince of Wales Island, between Moira and Cholmondeley sounds. It is perhaps the best known from the settlement Dolomi, on its north shore. A few years ago in this region considerable gold mining as well as marble quarrying was done, but last summer only one mine was in operation and the settlement was nearly abandoned. The Valparaiso mine was the only mine in operation, but several prospectors, in so far as their slender resources would permit, were actively developing their holdings.

The Valparaiso mine is situated on the north shore of Paul Lake, about 1¼ miles northwest of Dolomi. The lake is connected with the town by a narrow-gage track, from the end of which the mine may be reached by a trail along the shore or by a small gasoline launch. The country rock in the vicinity of the mine consists almost entirely of limestone with here and there silicified zones and quartz-impregnated rock. No other sedimentary rocks and no igneous rocks were recognized in the underground workings. The hanging wall of the ore body is in almost all parts of the mine a strongly marked slip seam, but no sharp plane of division occurs on the footwall, and the distinction between ore and waste is determined by assays.

A mill has been built below the mine near the lake shore. It is equipped with a battery of five Hendy stamps, but space has been arranged so that this number can be doubled without much alteration. The ore is crushed to 30 mesh and 90 per cent of the gold it contains is said to be caught either in the mortar box or on the plates of the battery. The pulp from the stamp is led by gravity to a Chilean mill, in which it is ground and from which it passes to classifiers. From the classifiers the fine material flows to slime tables, from which the tailings are discharged into the lake. Little metallic material is caught on the tables. Crushing by means of the Chilean mill after the ore had been reduced to 30 mesh in the stamps is said to increase greatly the capacity of the mill over that obtained by the more usual practice of crushing to 40 mesh in the stamps.

One of the problems confronting the economical development of this property has been to acquire cheap power. At present wood costs about $2.50 a cord, but by the time it is delivered at the boiler it costs nearly $6. A solution of this problem that has been considered is the development of water power from a subterranean stream which debouches on the hillside several hundred feet above the lake. This water evidently comes from a lake that lies to the north. Apparently it flows through a passage in the limestone that forms the country rock, appearing at the surface again where the limestone gives place to schist. The operators of the mine estimate the volume of this stream's discharge at 150 to 600 miner's inches. If as great a volume of water is available throughout the year, it would be a source of considerable cheap power.

East of the Valparaiso and west of the tramroad to James Lake a number of claims have been staked, on many of which considerable work has been done in the past, but at present they are idle. Several veins have been distinguished by the prospectors and given different names. Casual examination of the region seemed to indicate that many of these distinctions are unwarranted by the information now available, and the belief is expressed that practically all represent the same general shattered zone. The character of the mineralization in all the area is essentially the same, although the amount differs considerably in different places. As a rule the gangue minerals are similar throughout the area, but on the Pauline claim, in addition to the common minerals, greenish, slightly translucent, compact muscovite was observed.

East of the tramroad to James Lake a little prospecting has been done on the Beauty claim, about half a mile north of Dolomi, and on the Fortune and Moonshine claims, about a quarter of a mile farther north. The Fortune and Moonshine claims lie near the contact of a dark quartzite and metamorphic limestone. The quartzite is intersected by numerous and irregular quartz veins, which range in width from mere films to 12 inches. Usually the vein quartz is glassy and crystalline. The gold recovered is native and occurs in the quartz veins and also in the graphitic quartzite contiguous to the veins. Some gold is reported to have been found on the surface of the quartz crystals. The vein gold is said to be worth about $16 an ounce. Sulphides are more apparent in the vein material from this deposit than in that found on most of the other prospects examined and are composed mainly of pyrite and gray copper. A small production has been made from this property by a prospector, who has pounded up selected ore in a hand mortar and recovered the gold by panning.

MOIRA SOUND AND VICINITY.

Prospecting in the vicinity of Moira Sound amounted to little more than the annual assessment work required by law. Between the head of North Arm and Mineral Lake the copper mines, once active, were idle throughout the year and the only person in the region was a man who looked after the various properties and as opportunity offered did a little prospecting. Efforts have been made to prospect further the Navaho claim, formerly called the Hope claim, which lies between Cannery Cove and North Arm. No important new discoveries, however, have been made at this place.

No productive work was done during last year on any of the properties adjacent to Niblack. Only one person now lives in this region, and although part of his time is spent in prospecting little new work has been accomplished. Reports were current that plans were under way to reopen the Niblack mine, but they were not verified. The strongly faulted and deformed structures in this region undoubtedly will increase the difficulty and expense of mining.

A small prospect hitherto not reported lies in the small bight north of Black Point, at the entrance of Niblack Anchorage. The lead had been opened by means of a vertical shaft, now full of water, and by a short adit. The country rock is an agglomeratic or pyroclastic igneous rock trending east and dipping south. Not far away an infaulted mass of black shales and slates was exposed. Work at this place had been abandoned only a relatively short time, but the exposures did not seem to be sufficiently encouraging to warrant further development at present.

M'LEAN ARM AND MALLARD BAY REGION.

Seven miles north of Cape Chacon, the extreme southern point of Prince of Wales Island, is McLean Arm, a fiord about 5 miles long. A slight indentation immediately south of this arm is called on the charts of the Coast and Geodetic Survey Mallard Bay, but according to local usage this name correctly applies to the next bay south, which is called on the charts Stone Rock Bay. Without presuming to decide which of these names is correct, the writer has accepted the nomenclature adopted for the charts, and in the following notes the name Mallard Bay is used for the first bay south of McLean Arm.

The country rock in the neighborhood of McLean Arm is composed chiefly of a medium coarse-grained granodiorite, similar in physical aspects to the intrusive rocks of the Coast Range farther east. South of Mallard Bay the country rock is also igneous in origin, but differs from that to the north in that it is much more porphyritic. It may be of the same age as the granodiorite and may possess a different appearance because of having cooled under different conditions. Between these two areas of deep-seated igneous rocks is belt of greenstones and greenstone schists. The relation of the greenstone to the granitic rocks was not apparent in the exposures examined, but the impression gained was that the greenstone had been brought into its present position by faulting. The greenstone outcrops along the south shore of Mallard Bay and its trend is slightly north of west, so that it is again exposed near the head of McLean Arm.

Along the belt of greenstone claims have been located. These are, from east to west, the Veda group, the Apex-Adit group, the Hillside, and the Wano. Although the claims have been located a number of years, none had been brought to a producing stage and none is being developed continuously. Copper is said to be the main metal of value in the ore and occurs as chalcopyrite. This sulphide is most abundant in the greenstone and schist, but in places it is also found in the granitic rocks.

A little prospecting has also been done farther south in the vicinity of Stone Rock Bay. This place was not visited, but from reports of prospectors the country rock is dominantly the same porphyritic granitic rock that occurs south of the belt of greenstone. A short distance northwest of the head of the bay claims are being prospected by Decker and West, and about 2 miles from the head of the bay on the north shore of a small lake are claims locally known as the Hanson prospect. The main metal of value recovered from the ore is reported to be copper, but no reliable information as to the tenor or extent of the deposits was obtained.

HETTA INLET AND VICINITY.

The region near the head of Hetta Inlet has long been the greatest producer of copper ore in the Ketchikan region. Although it still produces the greatest quantity of copper ore, mining activities have dwindled, until in 1913 it contained only one producing mine. This mine, the Jumbo, owned by the Alaska Industrial Co., is located about 3 miles south of the town of Sulzer. About 50 men are employed more or less continuously throughout the year. The ore is delivered by an aerial tram from the mine to bunkers at the wharf, from which it is loaded onto ocean-going steamers and transported to the Tacoma smelter. No notable developments occurred during the year, and mining was carried on at the same places and with the same general results as in the past. The facts regarding the geology and mining developments in the neighborhood of this mine have been given in considerable detail by Wright[1] in a recent report and will not be repeated here.

---

[1] Wright, C. W., Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska: U. S. Geol. Survey Prof. Paper 87 (in press).

The Copper Mountain group of claims, formerly an important copper producer, lying south of the Jumbo claims, was not visited by the writer. To judge from reports, none of these claims were productive in 1913. Prospecting, however, was carried on at several places on this property, and some ore that seemed to promise well is reported to have been found. No indications that work will be resumed on this property in the near future were seen. The geology and mineral resources of this group of claims have also been fully described in the report by Wright mentioned above.

Near Lime Point, at the extreme southern entrance to Hetta Inlet, a little prospecting has been carried on. As yet, however, not enough has been accomplished at this place to show the character and extent of mineralization.

BIG HARBOR MINE.

On the west coast of Prince of Wales Island, near the head of the bay locally called Big Harbor but on the Coast and Geodetic Survey charts called Trocadero Bay, lies the Big Harbor mine. This place was not visited, but the following notes, gathered from a number of sources, afford what is believed to be a fairly accurate description of the general developments.

Big Harbor mine may be reached directly by ocean-going vessels, as deep water extends all the way up to the company's wharf. No ships except those under special charter, however, call at this place, so that it is rather inaccessible. The air-line distance from salt water at Trocadero Bay, on the west side of Prince of Wales Island, to salt water on Twelvemile Arm, on the east side of the island, is less than 10 miles. A trail over a relatively low divide connects these two bays.

The main underground developments consist of two shafts, each of which is about 50 feet deep. These shafts are situated about one-third of a mile from the beach, at an elevation of about 250 feet above the sea, and about 190 feet of crosscuts and 180 feet of drifts have been driven from them. Stopes have been blocked out and during the year some ore was shipped from this property to the Tacoma smelter. The ore is mainly valuable for its copper content, but it also contains accessory values in gold. According to Knopf,[1] "the ore was reported to consist of chalcopyrite in a lime gangue, but the samples shown to the writer proved to be a highly siliceous, sericitic schist, carrying disseminated chalcopyrite and pyrite. Some ore rich in black zinc blende was seen that came from the same locality." The ore as shipped is reported to contain normally less than 20 per cent silica and slightly more than that amount of iron. No

---

[1] Knopf, Adolph, Mining in southeastern Alaska: U. S. Geol. Survey Bull. 480, p. 102, 1911.

reliable information as to the character of the country rock has been obtained. At Soda Springs Bay, 10 miles to the south, carboniferous limestone outcrops; less than 10 miles to the north Upper Devonian limestones, argillites, and quartz are exposed on Klawak Inlet, and less than 10 miles west of Big Harbor Upper Devonian limestone is exposed on San Juan Bautista Island. In other parts of Prince of Wales Island rocks of approximately the same age are strongly mineralized. The conclusion that the rocks occurring in the vicinity of the Big Harbor mine are of this same general age, namely, late Paleozoic, seems justified.

MAINLAND.

SMUGGLERS COVE PROSPECTS.

On Cleveland Peninsula the two main places at which mining has been active in the past are at the head of Smugglers Cove and on the west side of Helm Bay. These bays indent the southeastern coast of Cleveland Peninsula and are 25 to 30 miles northwest of Ketchikan. At the time of the writer's visit no mining was in progress in the vicinity of Smugglers Cove, but later in the season several of the claims were reported to have been purchased by a company that proposed to actively develop them. Exact information regarding this enterprise is not yet at hand, and consequently the operations are not discussed in this report.

On the Old Glory claim, which lies about 1¼ miles northwest of the head of Smugglers Cove, several openings have been made. The new camp is built at an elevation of about 900 feet, and near it is a crosscut 110 feet long, from the inner end of which a 70-foot drift has been turned off to the south. The lead trends about N. 20° W. and dips steeply west. The vein consists almost entirely of quartz and contains only a small quantity of sulphides. Free gold was observed in several of the specimens and is said to be sufficiently abundant to warrant mining. Southeast of the new crosscut and drift is an old adit, now somewhat caved, 75 feet long. To the left and slightly lower is another adit on the same vein. The presence of the vein between the two adits has been proved by means of several prospect pits. The country rock throughout this group of claims is greenstone schist, with numerous quartz stringers. Samples of the disintegrated material on the surface near the vein disclosed many small particles of gold. Facilities were not at hand for determining whether this gold was entirely derived from free gold in the vein or had been originally carried in the sulphides and separated from them by oxidation.

West of the Old Glory claim is the American Eagle claim. On this property a short crosscut has been driven and drifts, each 100 feet long, have been turned off to the northwest and southeast. The vein trends about N. 35° W. and dips south. The country rock appears to be the same as that on the Old Glory claim.

About half a mile west of the American Eagle claim is a property formerly called the Keystone, later known as the Bradley, and now named the London claim. The underground developments at this place consist of a crosscut 150 feet long, trending N. 30° E., from which drifts have been run 120 feet N. 60° W. and 105 feet S. 60° E. An old raise connects the inner end of the crosscut with the surface. The dip of the vein is in general very steep toward the northeast, but in places it is vertical. The vein is split into numerous quartz stringers, which show considerable slickensiding. Calcite and siderite are associated with the quartz in the gangue. The main value of the ore is reported to be its free gold content. A fine water-power site is located near the coast about 1¾ miles from the mine. Two falls, the upper one 25 feet and the lower one nearly 75 feet, not more than 500 feet distant from each other, discharge sufficient water into the head of Smugglers Cove to furnish a very economical means of supplying power for mining and milling.

HELM BAY AND VICINITY.

The Gold Standard group of claims on Helm Bay was at one time the scene of considerable mining activity, but no work has been done there for six years. Many of the buildings and a large part of the tram line that was built on trestles have collapsed, though the mill still seems to be in fairly good condition. The ownership of the claims is said to be in dispute, and this is given as one of the reasons why the property is lying idle. A little prospecting was done in 1913 at a place about a quarter of a mile from the shore by one man, who was stripping a series of quartz stringers that trend N. 10° E. and dip 60° W. Considerable pyrite occurred in the veins. The stripping had exposed a width of about 15 feet, and through this distance small quartz stringers formed an irregular network.

Some placer gold has been obtained from the hillside detritus near the main shaft of the Gold Standard group by a placer miner, who worked on the ground a considerable part of the summer. The gold occurs in rather angular semicrystalline aggregates, and many of the pieces have quartz and chlorite schist adhering. These characteristics point to the conclusion that the gold has been little transported and probably is a residual placer below the outcrop of the vein rather than a normal creek placer. The gold is said to be 920 fine. Only a small production was made, as much of the promising area had been covered by the waste dumped from the lode mine above.

West of the head of Helm Bay and three-fourths of a mile inland occurs the contact of black slates with the greenstone that forms much of the country rock to the west. A lake half a mile long lies near this contact, and the hills rise steeply to the northeast and southwest. West of the lake one group of claims has been staked but has not been prospected. East of the lake occur numerous small gold-bearing quartz stringers, several of which have been sampled and are reported to carry gold in commercial quantities, but none of them has been opened up. On the Quartzite Ledge claim an adit had been driven a few feet on a greenstone which contained a small amount of calcite and disseminated sulphides. The leads, however, have not come up to expectations, and one by one the claims have been relinquished until now practically the whole region is open for location.

PORTLAND CANAL AND VICINITY.

The mining developments on Portland Canal were not visited by the writer owing to lack of time. Mr. W. S. Polsen, of Ketchikan, however, who is familiar with that region, furnished much of the following information. No production has been made from this district, but prospecting has received an impetus from the recent building by the Dominion Government of a road up Salmon River, through United States territory, to reach claims on the Canadian side of the line. This road has made the region accessible and has materially reduced the cost of transporting supplies into the mineralized area.

Most of the prospecting has been done in a belt of schists and metamorphic rocks that lies along the inner or eastern margin of the great area of intrusives which form the country rock westward along Portland Canal. The belt of schists is wedge-shaped, being bounded on the east by a smaller granitic mass which lies 1 to 5 miles east of the main mass of the western intrusive. Numerous smaller intrusives also cut the schists. The schists apparently form the continuation of the rocks which in British Columbia have been called by McConnell[1] the Bear River formation and described by him as comprising "porphyrite, tuff, breccia, agglomerate, etc."

Mineralization is reported to be widespread and occurs both in distinct veins and in mineralized zones. Pyrite is the most common metallic mineral and is even more abundant in the schists than in the veins. Gold is the main valuable mineral for which this type of deposit has been exploited. Certain of the prospects have been developed on deposits whose main metallic mineral is galena. This type is principally valuable for the silver contained in the ore.

---

[1] McConnell, R. G., Salmon River district: Canada Geol. Survey, Dept. Mines, Summary Rept. for 1911, pp. 50–56, 1913.

As only a small amount of work has been done on any of these prospects little has been definitely determined about the ore—its commercial tenor, its persistence in depth, its mining or milling qualities are still unknown. In regard to the persistence of the ore in depth it should be remembered that although most of the mineralization is in the schists some occurs also in the granite. This condition indicates that the ore bodies are not necessarily limited in depth by the granite but extend into it. To what depth this penetration goes should be carefully determined. In a region like that at the head of Portland Canal, where the granitic rock nowhere lies very deep below the surface, the determination whether or not the mineralization cuts certain of the batholithic masses is important.

REVILLAGIGEDO ISLAND.

LONDEVAN MINE.

The only mining on Revillagigedo Island during 1913 was done on George and Thorne arms. On George Arm some mining was done at the Londevan property, on the west side of the bay, about 10 miles from the head, and work was continued at the Peterson prospect, 3 miles farther south, and at the Mahoney prospect, which was formerly known as the Ash prospect, about the same distance to the north.

At the Londevan mine six men were employed until the later part of May. The mine was then closed and, according to report, has not been reopened. No ore was shipped from this property but has been dumped in a stock pile near the water's edge. In the early development of the property numerous surface excavations disclosed ore that seemed to promise well. Difficulty in developing the deposits by shafts led to the driving of a long crosscut from a point near sea level to intersect the vein in depth. The crosscut was started about 185 feet above the sea on the Portal claim and was driven about S. 75° W. more than 2,000 feet to the vein and drifts turned off to the north and south. Several small veins were intersected in the crosscut; one at 850 feet from the entrance was about 18 inches thick, one at 1,000 feet was about 2 feet thick, and one at 1,200 feet beveled the crosscut at an angle, so that its thickness was indeterminate but considerably greater than that of the preceding veins. Between these last two veins are two fault zones, one tending approximately east and the other more nearly north. These faults have afforded planes along which water penetrates freely. In consequence this part of the crosscut is wet, but the water is readily carried off by the slope of the crosscut.

About 800 feet beyond the vein last noted is the main vein. At the place where it was first cut it was 3 to 4 feet wide and dipped westward. Drifts were turned off on it, the one to the north being over

500 feet long and the one to the south about 1,800 feet long. The vein in the northern drift consists of a number of small stringers, which separate and unite in an intricate fashion. A strongly marked plane of movement appears to form the footwall of the vein throughout the northern drift. At the north end of the drift the vein gradually narrows until it almost entirely disappears, but the footwall fault plane continues. At the north end of this drift a crosscut has been driven west and a large mass of white, glassy, little-mineralized quartz disclosed. In the southern drift the hanging wall is remarkably smooth and appears to be a fault plane, dipping about 65° W. At the face the vein is much broken, and considerable water comes into the mine along the fracture planes. At the face the quality of the ore is said to improve, and the width of the vein is fully as great as at any other place in the mine.

The country rock throughout the mine is dark schist with a greasy graphitic luster. The cleavage planes are not strongly contorted and appear to dip in a uniform direction, except in those places where later faulting has interrupted the normal inclination. No granite or limestone was recognized in the underground workings. All the schist is more or less mineralized with iron pyrite. In fact, it is difficult to obtain even a hand specimen that does not show cubes of this mineral. This condition is rather surprising, for the veins do not show a large amount of pyrite. Sulphides, it is true, occur in the veins, but at a rough estimate they form less than 5 per cent of the volume. Pyrite is the most abundant of the sulphides, but some sphalerite, galena, and a very little copper pyrite were also recognized. Much of the gold reported to occur in the vein is said to be native, but no careful test of the quantity carried in the sulphides has been made. The gold tenor is said to increase markedly in those places in the vein where galena is abundant, as at the end of the southern drift.

The average tenor of the ore was not disclosed, but it is regarded by the owners as rather low. The estimated back of ore above the crosscut level of over 1,000 feet, the convenient shipping facilities, and the good surfaces to break to in mining should permit development at a rather low cost. Much money has been spent on the property, but even more will be required to develop the mine to a producing stage. The need for additional outlay probably has caused the temporary shutting down of the property.

MAHONEY PROSPECT.

The Mahoney prospect is on the small bay on the west side of George Arm, about 3 miles north of the Londevan mine. A drift about 25 feet long has been driven N. 15° W. on some mineralized stringers that can be traced underground for nearly 175 feet. The last 75 to 100 feet of this drift lies in barren rock, with no signs of mineralization. At the northern end of the drift a strongly marked fault trends N. 75° E. This fault has been followed for a short distance east and west of the drift as though in an attempt to find the vein. The search apparently was not successful and was abandoned. The country rock in the drifts and crosscuts is mainly rather heavy, dark-colored blocky schist, but near the shore a nearly black ottrelite schist and farther to the northeast a schistose conglomerate are exposed. A small amount of limestone also outcrops in this neighborhood.

On the hillside above the prospect is a narrow stringer carrying some galena, which occurs both in well-formed crystals and in compact fine-grained masses. The vein is narrow, in few places being more than about 8 inches wide. It has been traced by numerous shallow pits and trenches for several hundred feet. The ore thus exposed is much superior to any seen in the underground workings. In general the dip of the vein is rather low. Not far away is a small mass of granite, which from its nearness suggests a genetic relation to the vein.

PETERSON PROSPECT.

The Peterson prospect, formerly called the Surprise group of claims, is situated on the west side of George Arm, about 2 miles south of the Londevan mine. Only a little work has been done there lately. Practically the only mining has been the opening near the shore of two drifts north and south of the creek. The northern drift is about 35 feet long and trends N. 25° W.; the vein exposed in it dips about 70° E. Considerable shattered quartz appears on the footwall, but the drift is driven on a much-brecciated black mineralized schist similar to that forming the country rock at the Londevan mine. As at the Londevan mine, the quartz appears to carry rather smaller amounts of sulphides than the schists. The sulphides in the country rock are almost exclusively pyrite, but in the vein they are pyrite, galena, sphalerite, and copper pyrite. The relative abundance of these minerals is approximately in the order named, pyrite being by far the most abundant.

THORNE ARM PROSPECTS.

About two-thirds of a mile northeast of the head of Moth Cove, a small bay on the west side of Thorne Arm near the entrance, are claims of the Gold Standard Mining Co. These claims are located on the belt of calcareous schists that lie northeast of the mile-wide granitic intrusion which outcrops along the shores of Moth Cove. The dominant structure of the schists is their cleavage, which strikes in general N. 68° W. and dips at rather low angles to the south. The vein on which most development work has been done trends parallel to the schist but dips at a much higher angle. Mining developments at this place consist of a 75-foot drift, from a point near the center of which a 100-foot winze has been sunk at an angle of about 45°. The winze is driven at a flatter inclination than that of the vein and consequently the lower part lies in barren country rock which the operators believe is a few feet above the vein.

The vein in places is said to have been 5 feet wide, but in the breast of the drift the width was about 18 inches. The gangue is mainly quartz with subordinate quantities of calcite. Pyrite is the most abundant metallic mineral, but the ore is reported to carry about 5 per cent copper in the form of sulphide. The ore is mined both for its copper and gold content. The gold in the ore is said to be equal in value to the copper.

Work at this place has been in progress more or less intermittently for three years, but no ore has been shipped and seldom have more than three or four men been employed. A small 6-horsepower gasoline hoist is the only machinery as yet installed. So far only a little water has been encountered and the walls stand well without timbering, so that mining expenses are not heavy.

On the Sealevel group of claims at the head of Thorne Arm no work has been in progress for about nine years, and at the time of the writer's visit only a caretaker was living in the region. The buildings are fast falling into ruins and many have already collapsed, burying and still further wrecking the machinery that they contained. The only recent prospecting was done on some claims about three-eighths of a mile from the beach. This work was done during the winter of 1912–13 and accomplished little more than exposing some mineralized vein material. The vein was similar to most of the gold quartz veins of southeastern Alaska in that it was not strongly mineralized with metallic sulphides. It was considerably fractured, but so far as exposed was not much dislocated. Between this claim and the beach were numerous large bowlders of glassy white unmineralized quartz that undoubtedly have not been transported far.

MISCELLANEOUS LOCALITIES.

In the past prospecting has been carried on at some places on Dall Island, on Annette Island, and on Gravina Island, but in 1913 practically no work was in progress at any of these places.

DALL ISLAND.

Dall Island lies off the southwestern coast of Prince of Wales Island. Copper and gold have been discovered at several places on its eastern coast and in the past have been most extensively developed on the Mount Vesta group of claims. This property was idle in 1913, but a little prospecting was done on a group of 12 claims on Baldy Mountain that are situated near the contact of a granite and limestone northwest of the Mount Vesta group. Near the head of Sea Otter Harbor, a bay on the west coast of Dall Island between Juel Point and Cape Lookout, prospecting on the Moonshine claim has disclosed galena ore that is said to carry a considerable amount of silver. Developments at this place, however, have as yet not been sufficient to demonstrate the extent or quality of the ore.

ANNETTE ISLAND.

Many years ago Annette Island was given to the natives and prospecting or mining by whites forbidden. This prohibition has led to considerable dissatisfaction, owing to the circulation of tales of fabulously rich mineral deposits. Before the prospectors were ordered off some work had been done at several places on the eastern side of this island, notably about 1½ to 2 miles inland from the head of Crab Bay and along the western shore of Cascade Inlet. At all these places mineralization was seen, but its amount as disclosed in the pits and excavations, which presumably had been made on the most promising leads, was not great enough to warrant much further exploitation even if the island were open for mining location. At scores of places in other parts of southeastern Alaska fully as extensively mineralized areas are lying unstaked.

In the mineralized area on the west shore of Cascade Inlet gold is the main valuable mineral. It occurs both native and associated with sulphides in quartz veins in the contact zone between dark graphitic schists and nearly black, less deformed slaty shales. The native gold is said to have been particularly abundant near the contact of the veins and the country rock. Pyrite and gray copper are the most abundant of the sulphides. They form, however, probably less than 1 per cent of the vein material and are distributed mainly in narrow stringers, apparently along fracture planes in the quartz.

The mineralized area west of Crab Bay lies near the contact of limestone and quartzose schist. Gray copper is the principal metallic mineral. It occurs in disseminated particles and in narrow stringers, of which the largest seen was less than half an inch wide and a foot long. Associated with the gray copper is a small amount of galena and pyrite. At most of the openings no distinct quartz veins are recognized. On the old Tyee claim, however, there was a shattered zone in which some quartz and sulphides had been introduced. At this claim some barite, a mineral nowhere else noted in the region, was recognized in stringers several inches wide, but its relation to the quartz and sulphides was not determinable. The drainage at this place is noteworthy, for two lakes, each a quarter of a mile or more long, discharge eastward by means of a subterranean river whose course is determined by a belt of soluble limestone. After flowing nearly half a mile underground this water again appears at the surface east of the hills that apparently form a barrier to the eastward discharge of the lakes.

GRAVINA ISLAND.

Gravina Island lies northwest of Annette Island and west of Revillagigedo Island. Formerly some mining was done near Vallenar Bay at the north end of the island, near Gravina Point on the east coast, near Seal Cove on the southeast coast, and at a small bay on the west coast a short distance north of Dall Head, but at none of these places was mining in progress in 1913. The old prospect on the south shore of Vallenar Bay has been long deserted. The Goldstream mine, north of Gravina Point, was reopened a short time ago, but inadequate capital and other difficulties caused an early abandonment of the venture. A few shallow pits, which disclosed somewhat mineralized rock, were noted south of the Goldstream mine, but these represented little more than the annual work required by law.

When Seal Cove was visited in May no work was in progress, and not even a caretaker was living on any of the properties. The buildings and equipment, however, were in a good state of preservation, and a resumption of activities was anticipated in the near future. The main development at this place consists of a crosscut tunnel over 2,000 feet long, driven westward from a point near the shore. Four or five leads were intersected in the tunnel, and each of them has been somewhat explored by short drifts or raises. Sulphides are common not only in the veins, but also in disseminated particles throughout the country rock. The sulphides in the veins are mainly chalcopyrite and pyrite, but those in the country rock are dominantly pyrite. Subordinate quantities of gold are also reported to occur in the more mineralized areas. The rocks traversed by the crosscut are mainly igneous and have diverse compositions, trends, and inclinations. All of them are considerably jointed, and many of them are strongly slickensided. They stand well, however, and in the crosscut require little or no support by timber.

In the small bay on the west side of Gravina Island, about 2 miles north of Dall Head, some prospecting for copper has been done in the past, but the finds apparently were not satisfactory, for no work was in progress last year. The place, however, is interesting to the geologist, for in 1913 in certain of the rocks near the prospect holes Triassic fossils were found. The presence of these fossils determines the lower age limit of the mineralization of this part of Gravina Island and corroborates the previously theoretically deduced conclusion that the age of part at least of the mineralization in the Ketchikan precinct is Mesozoic. Similar rocks containing specifically identical fossils extend several miles north of this bay and include the previously reported but now abandoned prospects about 6 miles north of Dall Head.

MARBLE RESOURCES OF THE JUNEAU, SKAGWAY, AND SITKA DISTRICTS.

By Ernest F. Burchard.

INVESTIGATION.

In the autumn of 1912 the writer made an examination of the marble areas on Prince of Wales, Kosciusko, Marble, Orr, Tuxekan, Heceta, Ham, and Revillagigedo islands, and in the autumn of 1913 this work was extended to deposits on the mainland bordering Blake Channel, Stephens Passage, and Glacier Bay, on several islands in Glacier Bay, and on Chichagof and Admiralty islands. About nine weeks in all was spent in the field work of the two seasons, which involved cruising along about 1,500 miles of shore line in small gasoline launches. The results of the work completed in 1912 were published in Survey Bulletin 542,[1] and in the following pages notes are given concerning the occurrence of the deposits examined in 1913 lying north of Frederick Sound. The marbles of the whole area will probably be described later in more detail in a single bulletin.

The petrologic character of the intrusive and metamorphic rocks associated with the marble deposits was determined by J. B. Mertie, of the United States Geological Survey, and the writer herewith expresses his appreciation for this service.

TYPES AND DISTRIBUTION OF MARBLE.

Several types of marble are found in the Juneau and Sitka districts, including fine and coarse grained white, gray, and green marbles, schistose, banded varieties, and dense, noncrystalline limestone of various mottled colors. This paper will treat only of the macroscopic character of the marbles and will group the deposits geographically rather than by varieties, but it is expected that in the proposed bulletin the marble deposits will be described according to grades of fineness, because with the assistance of microscopic data,

---

[1] Burchard, E. F., Marble resources of Ketchikan and Wrangell districts: U. S. Geol. Survey Bull. 542, pp. 52-77, 1913.

which will be available later, the marbles can be more accurately classified than they can be through visual examination. The following table gives a rough outline of the most important marbles noted in the reconnaissance of 1913. The terms fine, medium, and coarse, describing the grain, are here used rather loosely. A marble is described as having a fine grain if its grain is just visible to the unaided eye or if it is still finer. A coarse grain is one in which the grain diameters range generally between 0.5 and 2 millimeters. The medium grain falls between the fine and the coarse. These three grades correspond to the six grades established by Dale[1] in his study of Vermont marbles, which ranged, according to his classification, from extra fine to extra coarse.

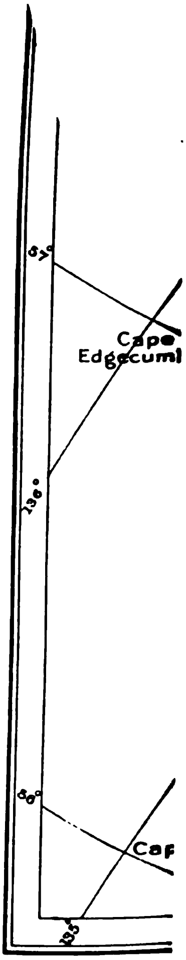
Distribution of marble, by varieties, in Juneau, Skagway, and Sitka districts, Alaska.

Color.	Grain.	Locality.	No. on Pl. III.
White and nearly white.	Fine	Glacier Bay, south of Sandy Cove, mainland	3, 4
		South Marble Island	7
		Basket Bay, Chichagof Island	11
		Chichagof Island, cove south of Basket Bay	13
		Marble Cove, Admiralty Island	15
		Admiralty Island, Hood Bay	18
	Medium.	South Marble Island	7
		Tenakee, Chichagof Island	10
		Marble Cove, Admiralty Island	17
	Coarse	North Marble Island	6
		Willoughby Island	8
		Tenakee, Chichagof Island	9
		Marble Cove, Admiralty Island	15
Gray	Fine	Glacier Bay, south of Sandy Cove, mainland	3, 4
		Basket Bay, Chichagof Island	11
		Cove South of Basket Bay, Chichagof Island	13
	Medium.	Glacier Bay, Sandy Cove	2
	Coarse	Willoughby Island	8
		Marble Cove, Admiralty Island	15
White and gray, banded and veined.	Fine	South Marble Island	7
		Basket Bay, Chichagof Island	11
		Beach south of Basket Bay, Chichagof Island	12
		Cove south of Basket Bay, Chichagof Island	13
	Medium.	Limestone Inlet, mainland	1
		Marble Cove, Admiralty Island	17
	Coarse	do	15
Schistose, varicolored bands.	Fine	do	15
	Medium.	Limestone Inlet, mainland	1
		Point Hepburn, Admiralty Island	14
		Marble Cove, Admiralty Island	15
	Coarse	Tenakee, Chichagof Island	9
		Point Hepburn, Admiralty Island	14
		Marble Cove, Admiralty Island	15, 16
Mottled	Fine	Glacier Bay, south of Sandy Cove	3
		Tenakee, Chichagof Island	10
Green	do	Glacier Bay, east of Sandy Cove	5
Blue	do	Basket Bay, Chichagof Island	11

As shown in this table, masses of marble occur in places on the mainland in the Juneau and Skagway districts and on several of the islands in the Juneau, Skagway, and Sitka districts, including Chichagof Island, Admiralty Island and certain small islands in Glacier Bay. The approximate locations of the deposits described below are shown on Plate III.

---

[1] Dale, T. N., The commercial marbles of western Vermont: U. S. Geol. Survey Bull. 521, p. 54, 1912.



GEOI

TOPOGRAPHIC AND COMMERCIAL RELATIONS.

The mainland and islands of southeastern Alaska are generally mountainous, and there is little level land either as upland area or along the shores. Along much of the coast line the hills and mountains rise abruptly and the dense forest growth, extending down to the level of high tide, overhangs the steep banks. The islands are separated by an intricate system of waterways and fiords, known locally as straits, canals, channels, passages, sounds, narrows, inlets, bays, coves, and arms, some of which reach far inland. Many of these waterways are very deep and can be safely navigated by the largest ocean steamers, but some are so shallow as to be navigable only at high tide by boats of moderate draft. The coast and entrances to harbors are rocky, and in places the greatest care is necessary in order to avoid rocks that are barely submerged. The topography is so rough that only in favored localities or at great expense can wagon or tram roads be constructed. The waterways are therefore of great value in affording routes of communication between different portions of the region and between this region and the Pacific coast ports of the United States. Indeed, were it not for water transportation the mining and quarrying industries in southeastern Alaska could scarcely have been developed.

Some of the deposits of marble are situated on the shores of sheltered bays that are deep enough to afford anchorage or wharfage for ocean-going freight vessels. Others, however, are on rocky, exposed portions of the coast, and still others are a mile or more from the shore and at considerable altitudes. Naturally the deposits most convenient of access will be developed first. Freight rates have been much reduced in the last few years through competition, and are reported at present to be moderate.

The rock surface is in general thickly overgrown with small to medium-sized timber and dense underbrush and has a soil cover of decayed wood, moss, and mold, from a few inches to 3 or 4 feet thick as a rule, but thicker in hollows and crevices in the rock. The timber consists of hemlock, spruce, and cedar, which have in few places a maximum diameter of more than 4 feet. At the north, in the vicinity of Glacier Bay, the timber is much smaller but the underbrush is dense.

Several marble quarries have been opened in the Ketchikan and Wrangell districts, although only one is being operated on a commercial scale,[1] but as yet no quarries have been opened in the districts discussed in this paper.

GEOLOGIC RELATIONS.

Most of the marble beds in southeastern Alaska appear to be portions of extensive belts of limestone that have been metamorphosed

---

[1] U. S. Geol. Survey Bull. 542, pp. 52–77, 1913.

either at or near the contact of an intrusive mass of granodiorite or else by the general metamorphism of the region. Both the limestone and the marble are cut in many places by thin dikes, principally of basalt, andesite, dacite, and diabase, all more or less altered and containing secondary calcite, and in places the marble beds are interstratified with schists and lavas. The limestone beds associated with the marble masses are of Paleozoic age and at a few places, notably in northern Prince of Wales Island and vicinity, have yielded fossils that are regarded as Silurian or lower Devonian.

MARBLE DEPOSITS.[1]

LIMESTONE INLET.

The deposits of marble in the vicinity of Limestone Inlet are about 2½ miles inland from the mouth of the inlet, or 1 to 1½ miles from deep water (No. 1). Outcrops on the north bank of Limestone Creek consist of medium-grained grayish-white marble, banded in places with dark-gray streaks and veins of white calcite of coarser texture. Portions of the beds have a grayish-green color, possibly due to surface stains. Some parts of the mass are schistose and carry hornblende, mica, pyrite, and thin veins of quartz. The gray and green varieties are both susceptible of a fair polish. The marble is cut by two or more sets of joints into blocks from a few inches to 3 feet thick. The strike of the rocks is apparently between N. 25° W. and N. 30° W., and the dip is steep toward the northeast.

Two groups of marble claims have been located on this deposit, and two small prospect openings about 200 feet apart have been made near the creek bank. Between these two openings several natural exposures in the bank of the creek indicate the presence of schistose marble.

With the exceptions noted the marble deposit is covered by forest growth, and little could be ascertained as to its extent or structure beyond the indications afforded by the few exposures. In order to develop this deposit a tramway must be built from the property down the creek to deep water in Limestone Inlet, a distance of about 1½ miles. The cutting away of some rocky points and the building of half a mile or more of trestle would be involved in the construction of the tramway.

GLACIER BAY.

Limestone and marble deposits outcrop on the mainland on the east shore of Glacier Bay in the vicinity of Sandy Cove. Along the north shore of Sandy Cove (No. 2) marble is exposed for 600 feet or more, and the deposit extends back into a low ridge 50 to 75 feet above the

---

[1] In the description of the deposits the numbers in parentheses refer to corresponding numbers on Pl. III.

water. This marble is hard, of a light-grayish color, and generally of medium grain but contains many small bodies of calcite of varying size. Nearly obliterated traces of fossil brachiopods were noted in it. The marble is brecciated in places and has been disturbed by the intrusion of dikes. Some of the brecciated portions contain magnesium carbonate. The beds here are 3 feet or more in thickness, strike northward, and dip about 40° W. Where exposed the material is so jointed and fractured that little stone of commercial size is obtainable.

Bordering the east shore of the cove next south of Sandy Cove (No. 3) are beds of variegated marble and partly metamorphosed limestone. The colors include gray with bluish veins, cream with yellow veins, reddish, mottled chocolate and pink, and mottled grayish green and drab. The rock is fine grained, hard, and brittle and takes a good polish. It is generally much fractured at the surface, especially the gray limestone. Traces of stylolites or suture joints were observed in the gray marble. The beds strike about S. 50° E. and dip steeply toward the northeast. This belt of rocks is about 500 feet thick and extends an indefinite distance southeastward into the mountains. The bedding of the rock is variable, but for the most part the rock is fairly massive. Dikes of diabase cut the beds in east and northeast directions, and the jointing runs generally in the same directions. The ridge which the marble forms is about 50 feet high at its northwest end, where a low cliff has been cut by the stream that flows into the cove, but toward the southeast the ridge rises to 500 feet or more in height within a quarter of a mile.

Three claims, aggregating 3,960 feet in length, were at one time located on the strike of these beds, although little assessment work appears to have been performed. The really desirable and commercially valuable stone is probably scarce, and much prospecting will be necessary in order to establish its true extent and value.

The bold cliffs on both sides of the entrance to the cove next south of Sandy Cove and also extending southward from it (No. 4) are composed principally of fine-grained, hard, brittle, much-fractured gray limestone, cut by many diabase dikes generally 2 to 10 feet thick. Along the contacts between the limestone and the larger dikes the limestone has been locally metamorphosed to white crystalline marble, but not much marble of this sort is available.

In the float near the mouths of the two creeks that flow into this cove, which drain mountain glaciers, there are many bowlders of good white and veined marble, and in the canyon of the northern of the two creeks, at about a mile from the mouth of the creek (No. 5), an outcrop of fine-grained grayish-green, partly metamorphosed limestone 10 to 12 feet thick was observed.

Two islands in Glacier Bay, North Marble Island and South Marble Island, are composed wholly of marble, and others, such as Willoughby and Sturgess islands, show areas of limestone and marble. The two Marble islands lie about 12½ miles south of the entrance to Muir Inlet and are about 1½ miles apart. According to Coast and Geodetic Survey chart No. 8306, North Marble Island (No. 6) is about half a mile in length from north to south and its greatest width is less than a third of a mile. The highest point is probably about 300 feet above the sea. The marble exposed in this island is yellowish to grayish and is stained along fracture planes. The rock is medium coarse in grain and on weathered surfaces is generally soft and friable. Some portions of the rock are cherty; other portions are brecciated. Thin dikes of a dark fine-grained volcanic rock which appears to be altered spessartite cut the marble beds. The strike of the beds is nearly north. The rock has been jointed and in places shows small folds. The island has been glaciated, but weathering has been active and has produced through solution of material along joint planes and rounding of intermediate portions a bowldery appearance over much of the rock surface. Most of the rock is bare, but in crevices there is a thin cover consisting of mossy soil and vegetation, and hollows where loose material can find lodgment contain small quantities of glacial clay, gravel, and bowlders. The island is surrounded by fairly deep water, but the shores are abrupt and afford no harbor.

South Marble Island (No. 7) is similar in character to North Marble Island, but is a trifle longer, being about three-fifths of a mile in length. The maximum width is less than half the length, and there is one indentation where the island is nearly cut in two at high tide. The maximum height probably does not exceed 250 feet. The marble here is mostly fine to medium-grained white material, although there is a little that is veined with gray, and a little is brecciated. A few small inclusions of fine-grained nonmetamorphosed limestone were noted. The marble takes a good polish. The rock is cut by a few dikes of diabase ranging from less than 1 foot to 3 or 4 feet thick. The general strike is north, and joints cut the rock in several directions. These joints are so numerous as probably to interfere with quarrying the marble at the surface. It is possible, however, that all of them may not extend to great depths. Part of the surface is bare and part is covered to a depth of a few inches to 3 feet with glacial débris supporting a growth of mossy turf and shrubs. There is some shoal water in the vicinity of South Marble Island.

Willoughby Island (No. 8) is in the western part of Glacier Bay, about 13 miles north of Icy Strait. It is about 4½ miles in length and 2 miles in width, and reaches a height of nearly 1,600 feet. The south half of the island is composed mostly of gray limestone. At about the middle of the east side a small area of marble projects into the bay. This marble is coarse grained, of cream and light-gray colors, and brecciated in places. Some patches of chert show on weathered surfaces. The marble is cut by dikes of greenish-gray micaceous, pyritiferous rock, probably dacite, and is jointed. In some places the joints are closely spaced, but in others there are masses of marble that show no joints for 20 to 30 feet. The gray brittle limestone south of the marble outcrop is closely fractured and jointed. The exposed marble extends for about 500 feet along the shore and rises to a height of 60 to 70 feet above the water. Near the shore the surface of the marble shows glacial grooves and striæ. Back of the wave-washed exposure there is a growth of shrubs and small trees.

CHICHAGOF ISLAND.

The eastern shore of Chichagof Island from Peril Strait northward to Icy Strait is composed largely of Paleozoic rocks, including limestone, sandstone, phyllite, schists, and greenstone lavas and tuffs. Between Peril Strait and Point Augusta there is considerable limestone and some marble. The most promising deposits were noted in Tenakee Inlet and in Basket Bay and vicinity.

TENAKEE INLET.

In the north side of Tenakee Inlet, from 1 to 2 miles east of Tenakee post office, marble is exposed at several places, in some of which it forms low bluffs 30 to 50 feet above the beach. There are also exposures on the banks of the large creek that flows into the inlet about a mile east of the village (No. 9). From a quarter to half a mile above the mouth of the creek the marble forms low steep bluffs. It is coarse grained and much fractured, and some of it is schistose. The color is mostly white, but some of it, especially the schistose parts, is white and green. This deposit was at one time located as a marble claim by persons sojourning at the Tenakee hot springs. On the beach (No. 10), about 1½ to 2 miles east of Tenakee post office, the marble exposed is brittle and hard and ranges from white to gray in color, some being gray and white banded, and there is also a little that shows mottlings of green and pink. It is generally of medium grain, but some, particularly the mottled stone, is fine grained. Specks of pyrite are present in places. The general strike of the rocks is northward, but the bedding is obscured by the folds and fractures, which are very prominent. The fractures are locally so close together that good hand samples can hardly be obtained from surface material. The marble is cut and impregnated by so much altered volcanic rock as to be of little value in some places, but in others it may be possible to find material suitable for quarrying. Except where exposed on the beach and in stream cuttings the marble is concealed by a heavy forest growth.

BASKET BAY AND VICINITY.

Basket Bay (No. 11) is a short, narrow arm of Chatham Strait about 8 miles south of Tenakee Inlet. Although only about a third of a mile wide and 1¼ miles long, it affords good anchorage and good protection to vessels. The marble in the vicinity of Basket Bay is chiefly of fine grain. With reference to color there are four principal varieties—gray, gray and white banded, white, and dark blue with calcite streaks. On the southwest shore of the bay the marble is exposed almost continuously. Here the rock is massively bedded but weathers to thin spalls. The strike is N. 30° W., and the dip is steep toward the northeast. Myriads of small fractures cut the surface rock into small rhombohedral blocks, and the seamed condition extends up into the bluffs back of the bay. The marble is cut and impregnated in many places with seams of altered hornblende andesite. There is probably an enormous quantity of marble in this vicinity. The deposit on the southwest shore of Basket Bay appears to extend to the top of the 2,400-foot peak southwest of the bay. The 4,000-foot mountain to the northwest, 4 miles from the head of the bay, appears to be composed of limestone or marble. This was not proved, but the appearance of the weathered summit and slopes strongly suggests calcareous rock, and the mountain is directly in the line of strike between the Basket Bay and Tenakee marble areas.

Marble beds form the shore of Chatham Strait southward from Basket Bay to the next small cove, a distance of more than a mile. Some of the marble exposed here (No. 12) is of excellent quality and is susceptible of a good polish. It is all fine grained and is generally banded with bluish gray and white. The beds strike N. 30°–35° W. and dip steeply toward the northeast. The rock is cut by many minute fractures above tide level, has been closely folded, and commonly shows flow structure. Small faults are strikingly brought out on polished surfaces. The banding, the folds, and the flow structure are beautifully shown on the wave-scoured beach. Nowhere, however, is the marble for any considerable distance free from joints or from basaltic dike material. The bluffs are steep here and are surmounted with forests.

At the point (No. 13) on the north side of the small cove mentioned above the marble is mostly fine grained and white, although there is a little interbedded light gray. It is rather soft and friable above tide level in the cliffs, where it has been subjected to severe exposure, but it presents a handsome appearance. The characteristic jointing, fracturing, and intrusion by dikes have affected the beds here in no less degree than in other places along this shore. At the head of the cove is exposed a fine-grained gray and white banded marble, which was traced three-quarters of a mile or more up the creek that empties into this cove. The beds are massive where unweathered, as, for instance, below high-tide level or below the level of the creek, but they show much fracturing where exposed to the weather. This condition suggests that the action of frost may have played an important part in opening fractures caused by strains. Flow structure and beautiful examples of folding are common. The whole area seems to have been impregnated with thin dikes of hornblende andesite and stringers after the folding occurred.

In order to definitely appraise the value of this interesting area of marble, considerable prospecting with the core drill will be necessary, trails must be cut into the interior, and the marble must be explored on the slopes of the mountains.

ADMIRALTY ISLAND.

The shores of Admiralty Island from Mansfield Peninsula to Chaik Bay and from Pybus Bay to the head of Seymour Canal are made up largely of limestone and schist. The general distribution of rocks along the shore line of this island is shown in Plate XXXIII of Bulletin 287,[1] although slight modifications should be made in this map as a result of recent observations. For instance, the "Marble Bluffs" on Chatham Strait, nearly opposite Tenakee Inlet on Chichagof Island, have been found to be composed of quartz monzonite, a light-colored granite rock, instead of marble, as heretofore popularly supposed. In parts of the limestone belts the limestone has been metamorphosed to marble, some of which is of good quality and some of which is schistose. Exposures of marble were examined on the west shore between Cube Point and Point Hepburn, also south of "Marble Bluffs" and in Hood Bay, and search for marble was made at many intermediate points and in Pybus Bay.

POINT HEPBURN.

From 1 to 1½ miles north of Point Hepburn (No. 14) extends an area of medium to coarse grained schistose marble, which is white with gray, green, and black schistose bands. It includes nodules and lenses of fine-grained rock that probably contain magnesium carbonate. In places along the schistose planes pyrite is abundant. The rock occurs generally in beds 2 to 5 feet thick, but owing to the schistose structure it weathers to thin bands on the edges of the beds. The

---

[1] Spencer, A. C., The Juneau gold belt, Alaska; and Wright, C. W., A reconnaissance of Admiralty Island, Alaska: U. S. Geol. Survey Bull. 287, 1906. This bulletin is out of stock at the Survey but may be purchased from the Superintendent of Documents, Washington, D. C., for 75 cents.

beds are cut by quartz veins and are interbedded with green schist. The rock takes a fair polish, but owing to the presence of the schistose bands the polish is uneven. The beds strike N. 50° W., and stand almost vertical. There has been some close folding, but for the most part the bedding or schist planes are flat. This exposure forms a low bluff for about half a mile along Chatham Strait, and the direction of strike carries the beds into a prominent ridge toward the southeast. On the beach the beds are not well situated for quarrying, as the bluff is steep and high tide reaches its base, but if the quality of the material should warrant exploitation, a quarry could probably be opened in the slope of the ridge and the product trammed to the cove near Point Hepburn, where anchorage for boats of medium draft is available.

MARBLE COVE AND VICINITY.

On Chatham Strait from 2 to 4 miles south of "Marble Bluffs," 1 mile north of a small notch in the shore which will here be called Marble Cove, is a deposit of marble possessing considerable scientific interest and possibly some commercial value. At this locality (No. 15) the marble is interbedded with bands of gray and green mica schist and white to gray, variously banded quartzite. The marble layers range from 1 inch to 3 or 4 feet in thickness. The schist bands are generally 1 inch to 5 or 6 inches thick, and some of the bands of quartzite are a little thicker, but rarely exceed 1 foot. The marble is medium to coarse grained and is gray, white, pink, and green. All of it is susceptible of a fair polish, and the quartzite takes a glassy polish. The beds strike N. 60°–65° W. and are nearly vertical. They are cut by small dikes of dark-green hornblende dacite which send out stringers between the schistose layers. Folds are also exhibited by the varicolored bands. This outcrop is exposed in a strip about 50 feet wide along the beach for a quarter of a mile or more and is partly submerged at high tide. It is bounded by a bluff which also contains alternate bands of marble and schist, the latter predominating. In strike with these beds, 1 to 1½ miles toward the southeast (No. 16), a similar body of banded marble, schist, and quartzite is exposed by a steep mountain stream.

The wave-washed beach exposures of this banded rock afford some sections of very attractive material, and if it can be quarried advantageously it should be possible to obtain a large quantity of material here that might be suitable for certain classes of interior decorative work. The matter of sawing and polishing this rock, which consists of alternating bands of material of variant degrees of hardness, is not so simple as in the case of a more homogeneous rock. However, large blocks of similarly banded schistose marble found on Moira

Sound, Prince of Wales Island, have been cut and polished and yielded very handsome finished slabs.

About a quarter of a mile to a third of a mile north of Marble Cove occurs another strip of attractive marble. The beds here also strike N. 60°–65° W. and stand nearly vertical. The total width (or thickness) of the exposure is 115 to 130 feet. It extends 500 to 600 feet along the beach and in places forms a bluff 40 feet high. From 40 to 50 feet of these beds at the northeast side consist of medium-grained gray marble, closely banded with thin dark-gray layers. The southwest 75 to 80 feet is coarse-grained yellowish-white and greenish-white marble. Dikes of basaltic rock cut the beds, but not so closely as to seriously interfere with quarrying.

At the north side of the entrance to Marble Cove is exposed a fine-grained white marble. The rock strikes N. 60°–65° W. but is so badly fractured that the bedding is indistinct. The quantity of this grade of stone seems to be small, as the material passes toward the north into coarser yellowish marble.

Another deposit of marble was noted on this part of the Admiralty Island shore (No. 17) about a third of a mile south of Marble Cove, just south of the mouth of a large creek. The marble is of medium grain and comparatively hard. Some of it is white and some is white and gray banded. Both varieties take a good polish. The outcrop extends for half a mile or more along the beach and forms a bluff about 50 feet high, back of which is a flat wooded terrace several hundred feet wide, developed on the marble. The marble at the base of the bluff is of a dazzling white color, having been smoothed and polished by the surf. The rock is massively bedded and strikes northwest. Joints and dikes cut the beds, but not closely enough to interfere with quarrying. A quarry could probably be opened conveniently on the terrace above the beach, but as there is no harbor at this point boats could be loaded only at times of calm water.

Adjoining this deposit on the south is an area of altered quartz diorite, shown on Plate XXXIII of Bulletin 287 as extending southward nearly to Parker Point. South of Parker Point to Chaik Bay is an area in which schist predominates and in which no desirable marble was noted except at Hood Bay.

HOOD BAY.

Some fine-grained white marble was noted in two places on the northeast shore of Hood Bay (No. 18), almost due east of Distant Point. In hand samples this is a very beautiful marble which takes a good polish, but its availability in large blocks and in large quantity is questionable. The marble is associated with schist and becomes schistose in the direction of the strike, which is apparently N. 70° E. The beds are rather slabby and dip about 20° SE., although the angle of dip is variable. The surface rock is jointed into small rectangles, a few inches to 2 or 3 feet across. Veins and eyes of quartz were noted in the marble. The first exposure measured about 500 feet between its borders of schist and possibly 100 feet on the strike, between mean tide level and the wooded bluff. When traced up the hill the texture was found to become schistose. At the second exposure, about a quarter of a mile to the southeast, the material is similar in character, but has been much fractured and carries considerable quartz in eyes and veins.

SUMMARY.

Factors controlling value.—The value of a marble deposit in southeastern Alaska can not be judged by small surface samples alone, although tests of such samples may be of considerable significance. The character of the deposit as a whole, or at least so much of it as will be required for a quarry, must be considered, as well as extent, color, lack of objectionable impurities, such as silica, pyrite, and argillaceous or organic matter, soundness, absence of fractures or joint planes and of intersecting dikes, facility of quarrying and loading on vessels, distance and freight rates to markets, and competition.

The feature that will probably cause the most serious hindrance to profitable quarrying in southeastern Alaska is the fracturing and jointing of the beds. Observations have shown that this condition is very prevalent at the surface in this region, and such quarrying as has been done has shown that the cracks extend 60 feet or more below the surface. It is, of course, possible that at greater depths sounder stone will be found, but it is not profitable to be obliged to reject a large percentage of waste simply because the percentage of available blocks of the requisite size is limited by the structure of the deposit. The excessive moisture and the influence of the dense vegetation in this region have softened the surface marble in places to surprising depths compared with those in other well-known marble regions.

The practical judgment of a competent marble quarryman is necessary to decide many of the questions relating to the availability of the stone. Cross trenching, a common form of prospecting to determine the surface extent of a marble deposit, must be supplemented in southeastern Alaska by the core drill. A careful study should be made, at the surface, of the directions or strikes of the various systems of joints, their minimum, maximum, and average spacing, the direction and angle of their dip, and the nature of the fracturing that is not related to the systematic jointing. A sufficient number of holes should then be drilled to such depths and in such directions that a definite idea may be obtained as to the character of the beds below the surface, especially in relation to fracturing and jointing and the hardness of the marble.

Tests of the cores, including chemical analyses, measurement of size of grain, absorption, porosity, compressive strength, and polish, are all of great value, but satisfactory tests for strength and polish may not be practicable unless the core is 2 inches or more in diameter.

Deposits of possible economic importance.—While some of the deposits of marble described in this paper possess elements of possible value, not all of them seem to warrant prospecting, and even those which have appeared most favorable on cursory inspection may prove on prospecting to be totally unfit for exploitation.

Of the deposits whose surface appearances suggested that further investigations might be warranted whenever the demand for marble on the Pacific coast exceeds the present production, the white to white and gray, moderately coarse grained marble a third of a mile south of Marble Cove, on the Chatham Strait shore of Admiralty Island (No. 17), seems to rank first. The terrace form of this deposit suggests a favorable site for a quarry. There is an abundance of timber and fresh water here, and although the harbor near by is small, breakwaters and docks could be constructed that would afford protection and facilities for loading vessels. Next in importance to this deposit is the white and gray banded marble in the vicinity of Basket Bay and the neighboring cove to the south, on Chichagof Island (Nos. 11, 12, 13). As is suggested on page 102, there appears to be a very large body of marble in this vicinity, and the larger the deposit the better should be the chances of finding a portion of it workable.

Limestone Inlet opens directly on one of the highways of travel, Stephens Passage, and is close to a base of supplies at Juneau; therefore, although the surface appearance of the marble 1 mile above the head of this inlet (No. 1) does not suggest a high quality of stone, it is possible that the hope of finding a good marble deposit in this advantageous location may warrant more thorough prospecting.

As to the remaining deposits little encouragement can be given regarding the possibilities of their exploitation under present conditions. For special ornamental purposes, where cost is a minor consideration, some very unusual marble may be obtained from the schistose deposits on Admiralty Island near Point Hepburn and north of Marble Cove, but it is doubtful whether these deposits can now be quarried profitably. About the shores and islands of Glacier Bay there are indications of an abundance of marble, but it is probable that the uncertainties of navigation in this bay and the scarcity of large timber will long retard active quarrying there.

A BARITE DEPOSIT NEAR WRANGELL.

By Ernest F. Burchard.

LOCATION.

An interesting deposit of barite was found by the writer in Sep- nber, 1913, on one of the Castle Islands in Duncan Canal, a long, rrow, shallow bay that extends northward into Kupreanof Island m Sumner Strait. The Castle Islands, which consist of a group of c or seven islets ranging from 600 feet to 1 mile in length, are about miles northwest of Beecher Pass, one of the entrances to Duncan nal. Duncan Canal lies 3 to 10 miles west of the well-known rangell Narrows, and the barite deposit is about 40 miles northwest the town of Wrangell, the distance being measured along the vigable waterway. The nearest port is Petersburg, at the north d of Wrangell Narrows, about 25 miles distant.

The approximate location of this deposit is indicated on the map l. III) which shows the marble deposits in a portion of southeastern laska.

FORM AND EXTENT.

The deposit of barite forms a rock mass on the east side of the cond island in the group, counting from the southeast. The mass ands as a block connected with the rest of the island by a low, rrow neck, about 200 feet long, that is covered by water to a depth 5 to 10 feet at high tide. The top of this barite outlier stands about feet above high-tide level. The mass as exposed is roughly elliptical shape, its major axis extending in a direction about N. 30° W. is possibly 75 feet wide by 200 feet long at the maximum. ee fig. 1.) Its extent below low water would be difficult to determine, d its thickness, measured perpendicular to the lamination, is un- rtain, but it is probably not less than 140 feet. Near the southeast d, which is narrow and more pointed than the northwest end, osion has cut a notch in the deposit to a point within a few feet of gh-tide level. Below the base of the cliff, which is washed by ex- eme high tides, the beach slopes away in all directions and at low le is 30 to 50 feet wide with the water level some 15 feet lower an the base of the cliff. All the visible part of this cliff and the rrounding beach, is composed of barite, either in place or as a talus deposit. A rough calculation, based on measurements by pacing, indicates that there should be more than 50,000 short tons of barite available above high-tide level.

There is little in the appearance of the mass or in its geologic relations and structure to suggest its nature or origin, but it may represent the residual portion of a large vein or lens of barite, extending parallel to the schistosity of the adjacent rock and representing the replacement of limestone by barite.

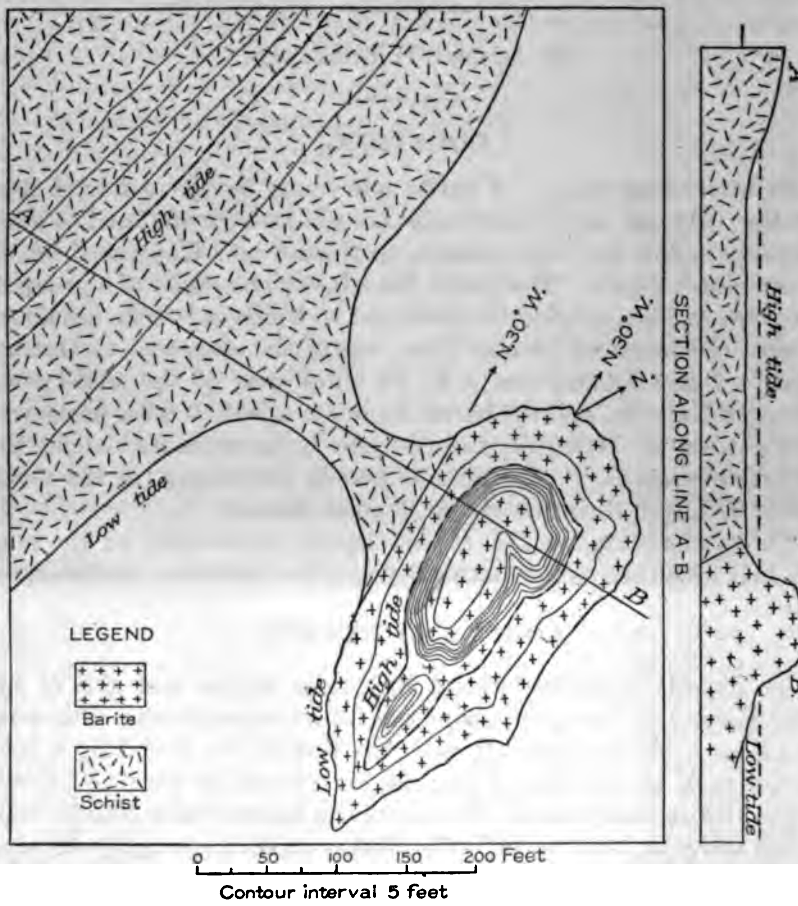


FIGURE 1.—Sketch map and section of barite deposit on one of the Castle Islands, Wrangell district.

GEOLOGIC RELATIONS.

The barite is very much jointed and is so fractured at the surface, probably by the action of frost, that the material is broken into fragments not more than 3 or 4 inches in thickness. The beds strike N. 30° W. and dip steeply toward the northeast. On the southwest side facing the island, a granular schistose rock is just visible at low tide. This schistose rock strikes N. 30° W. and dips steeply northeast, just as does the barite. The neck connecting the barite outlier with the rest of the island is composed of schistose material, which becomes finer grained and more thinly laminated toward the main part of the island. The island itself is composed mainly of schist.

The nearest islet toward the southeast, about 1,000 feet distant from the barite deposit and nearly in strike with it, is composed wholly of schist, and the next islet toward the northwest at a less distance is composed mainly of schist, together with some cherty limestone and veins of calcite. No other deposit of barite was observed and time was not taken to search for more, but the similar appearance of other cliffs on islands in the group farther north, as observed through a field glass, suggests the possibility of other deposits.

The schistose rock adjacent to the barite, and apparently dipping below it, is gray in color, granular in texture, crumpled to a slight extent, much jointed, and the grains have been flattened to a lens-shaped section. J. B. Mertie, of the United States Geological Survey, finds in a thin section of this rock the following minerals, all of which he regards as secondary: Chert, quartz, barite, a little plagioclase feldspar, a little mica, sulphides, and titanite. When treated with dilute hydrochloric acid, it emits an odor of hydrogen sulphide, but does not liberate carbon dioxide.

CHARACTER OF THE BARITE.

The barite, where fresh, is mostly a finely crystalline grayish-white rock with thin grayish-blue veins and clouded areas and a few thin black streaks. Exceptionally some of the barite is coarsely crystalline and white, and some white quartz is present in thin seams and small segregations. Pyrite is nearly everywhere present in fine specks disseminated through the mass or arranged in rough parallelism with the grayish-blue veins in the rock. The thin black streaks are segregations below the surface of the barite of fine specks of dark minerals, among which are probably galena, sphalerite, magnetite, and graphite. Molybdenite is also suggested but was not found by qualitative test. Grains of magnetite can be separated from the powdered rock by means of the magnet. At the surface the material is strongly stained with iron rust, resulting from the weathering of the iron pyrites.

Thin sections studied by Mr. Mertie showed the barite to contain titanite (in part leucoxene derived from ilmenite), iron oxides, and metallic sulphides. The powdered material examined under the microscope by E. S. Larsen showed, in addition to barite, quartz, sphalerite (?), magnetite, and metallic sulphides. The thin sections show the barite crystals to have been strained and granulated, and probably the barite was metamorphosed along with the bordering schist. The pyrite crystals appear to be secondary to the barite. The powdered barite is grayish white and under a hand lens shows many particles of metallic sulphides. Laboratory experiments outlined on another page suggest that with proper mechanical manipulation it may be possible to bleach the material on a commercial scale.

ASSAYS AND ANALYSES.

The presence of metallic sulphides in abundance warranted assays for the precious metals, and a sample weighing about 50 pounds was averaged from the surface of the deposit. According to the results of the assays, metals are not present in sufficient quantities to permit the barite to be classed as a metalliferous ore, and its commercial value consequently will depend on the quality and marketability of the barite itself.

The following results were obtained from two independent assays of the material:

Assays of material from the barite deposit near Wrangell, Alaska.

	Burlingame (Denver, Colo.).	Ledoux & Co. (New York City).
Gold .... ounces per ton..	0.03	0.060
Silver .... do....	.79	1.05
Copper .... per cent..	.05	.07
Lead .... do....	None.	.20
Zinc .... do....	1.27	1.14

The results of a quantitative chemical analysis by W. C. Wheeler, of the United States Geological Survey, are as follows:

Quantitative analysis of barite from vicinity of Wrangell, Alaska.

	Original analysis.	Recalculated analysis.
Silica (SiO_2)	5.05	5.05
Iron oxide (Fe_2O_3)	.77	.77
Titanium oxide (TiO_2)	None.	None.
Calcium oxide (CaO)	Trace.	Trace.
Magnesium oxide (MgO)	Trace.	Trace.
Barium oxide (BaO)	58.60	58.60
Strontium oxide (SrO)	.37	.37
Sulphur trioxide (SO_3)	34.74	33.69
Carbon dioxide (CO_2)	None.	None.
Lead oxide	.15	....
Lead sulphide (PbS)	....	.16
Zinc sulphide (ZnS)	....	1.68
Manganese dioxide (MnO_2)	Trace.	Trace.
	99.68	100.32

The original analysis showed a surplus of sulphur trioxide and the quantity of zinc sulphide was not determined, but its percentage was calculated as the equivalent of 1.27 per cent of zinc, as determined by the first assay. In like manner the percentage of lead sulphide was calculated by combining 0.15 per cent of lead oxide, which was found by analysis, with a sufficient quantity of the sulphur trioxide to form lead sulphide.

According to this analysis the material contains about 89.16 per cent of barium sulphate, or barite, and is therefore a little less than 90 per cent pure. The chief impurity is silica, and for many purposes for which barite is used, as will be outlined later, a moderate percentage of silica is not deleterious, nor is the strontia, which is too small in quantity to be separated. All the remaining minerals, which are mainly metallic oxides and sulphides, must aggregate less than 4.5 per cent, although only about 2.61 per cent is shown by the analysis. This is not a high percentage of objectionable impurity, and probably is below that carried by shipments of raw barite from many mines.

GENERAL NOTES ON BARITE.

MINERALOGY AND OCCURRENCE.

Barite (also termed barytes) or heavy spar is barium sulphate, the chemical formula of which is $BaSO_4$. The recorded occurrences of barite indicate that it is a mineral of aqueous origin and that it is formed as a direct deposit from waters or as a precipitate when waters of certain compositions mingle.[1] The pure mineral is composed of barium monoxide (baryta, BaO) 65.7 per cent and sulphur trioxide (SO_3) 34.3 per cent. The specific gravity is 4.3 to 4.6; the hardness is 2.5 to 3.5. Barite is usually a white, opaque to translucent, crystalline material, generally a little softer than calcite but harder than gypsum. It differs from both gypsum and calcite in its greater specific gravity and by the fact that it is practically not affected by acids. A common form of the mineral is an aggregation of straight or slightly curved cleavable plates, but it occurs also in granular, fibrous, and earthy masses, in the form of stalactites and concretions, as well as in single and clustered crystals. Few deposits of barite are wholly pure, the most common impurities being silica, fluorite, lime, magnesia, and the oxides of iron, manganese, and aluminum. The reddish and yellow stains, which are characteristic of much of the commercial barite when freshly mined, are due in large part to iron oxide. Fine crystals of galena and sphalerite are often found either disseminated or segregated in barite.

Barite occurs in veins in both sedimentary and igneous rocks as a gangue of metallic ores and also where it is the predominant mineral.

---

[1] Clarke, F. W., The data of geochemistry, 2d ed.: U. S. Geol. Survey Bull. 491, p. 555, 1911.

It occurs also as a cement between the grains of sandstone, as a replacement of limestone, as concretions in shale, and as a sinter deposited by springs. The deposits in the United States which at present supply the greater part of the output are situated in southeastern Missouri and in the Appalachian valleys of Georgia, North Carolina, Tennessee, and Virginia, where it is found generally in cherty and gravelly clay, residual material from limestone, dolomite, and quartzite.[1] Kentucky has vein deposits which are little developed.

A shear zone containing quartz and barite is reported by P. S. Smith to occur at the Tyee claim, 1½ miles west of Crab Bay, on Annette Island, in southeastern Alaska. The barite is white and has a granular crystalline texture, resembling the barite of the Castle Islands, but the largest clear piece of barite noted would measure only about 1 inch by 2½ inches.

Barite resembling the material from the Castle Islands in having a granular crystalline texture, though whiter in color, has been found in the mountains about 12 miles west of Hailey, Idaho, north of Deer Creek, according to L. G. Westgate, who reports that the deposit forms a vein which may be as thick as 200 feet but which can not be traced far on the strike. This deposit is associated with calcareous sandstones of Pennsylvanian age.

USES AND PREPARATION.

Barite is used principally as a pigment in mixed paints and in the manufacture of lithopone, a white pigment, but there are many other uses for small quantities of it, such as the manufacture of barium salts, which have a wide chemical application, the manufacture of rubber, wall paper, asbestos, cement, artificial ivory, enamels, and for covering packages of ham, cheese, etc.

The value of barite as a pigment[2] in mixed paints, if not used in excess, is due to its whiteness, its weight, and its inertness in the presence of chemically active substances, and also to its aptitude to take color stain uniformly and to make a small quantity of color, such as aniline, cover much surface. In order that the barite may be suitable for the uses mentioned above, it must be free from all associated minerals which do not grind white or which are affected by acids or atmospheric gases. Thus iron oxide and the sulphides of metals, such as iron, lead, zinc, and copper, must be removed, and there must be little lime or magnesia present. The presence of small percentages of clear or white quartz is not objectionable, for it grinds to a white powder and is chemically inert.

In the preparation of barite for the market in the mining regions of Missouri, where the largest quantities are at present produced, the

---

[1] See chapters on production of barytes in U. S. Geol. Survey Mineral Resources, 1907 to 1912.

[2] Burchard, E. F., Barytes as a pigment: U. S. Geol. Survey Mineral Resources, 1909, pt. 2, pp. [illegible], 1910.

ore is first allowed to stand in the sun and rain, so that much of the residual clay with which it is associated drops off, and hand cobbing, picking, and sorting results in such further cleaning of the material that it is ready for shipment to the mills. The product from some workings in the southern Appalachian region is first washed in log washers to free it of associated clay. Next the barite is separated into two or three grades by hand sorting, after which it is ready for the milling process. Neither of these preliminary processes would be needed for the Alaska barite herein described, as it would be ready for milling directly upon being quarried. Barite is milled by both the dry and the wet process.[1] The wet process is the later and more effective one and is now most generally employed. Several types of mills are in use. The milling consists of crushing, grinding, washing, bleaching, and drying, although not necessarily in the order given. The most troublesome impurities seem to be galena and limonite. Where the galena is disseminated in fine grains through the barite the two minerals are not easily separated by jigging or flotation. The limonite can not be entirely removed by ordinary jigging, and magnetic separation has been attempted but not yet accomplished. Bleaching, however, removes the iron, if that substance is not present in quantity so great as to require an excessive quantity of sulphuric acid, but it does not so readily affect the lead compound, which, when ground with the barite, imparts a grayish tint to the material and thereby reduces its value as a pigment. Lime carbonate is also a deleterious impurity when it occurs in sufficient quantity to require a portion of the acid to neutralize it in the bleaching process.

An outline of the complete process in one of the most thoroughly equipped mills in Missouri is roughly as follows: The crude material is ground in slip mills having granite grinders and granite bases. Water is fed into these mills and the ground material is floated over the top of the tanks, after which it is pumped into funnel-shaped separators. The contents of the separators are agitated by flowing water and the coarser, rejected material is drawn off at the bottom of the funnel and returns to the slip mills, whereas the finer material floats off at the top of the separators. This material next descends to settling tanks and after forming a sludge is drawn off into bleaching tanks. The bleaching tanks are built of concrete lined with refractory tile. Bleaching is accomplished by the addition of measured weights of sulphuric acid to the sludge and the agitation of the mass to secure thorough mixture. The acid reacts on the iron oxide and lime present, forming ferrous sulphate and calcium sulphate. The iron salt being soluble and the calcium salt partly soluble, besides having a lower specific gravity than pure barite, these substances,

---

[1] Burchard, E. F., The production of barytes in 1907: U. S. Geol. Survey Mineral Resources, 1907, pt. 2, pp. 686-687, 1908.

together with the excess of sulphuric acid, are removable in the further washing process to which the material is subjected. For this next washing the material is pumped into washers which employ the float-separation process. Next, the bleached barite passes to settling tanks, after which it is dried by being spread thinly on the surface of a rotating hot drum. From the hot drum the dried material falls or is brushed off and carried to Williams's mills, where it is pulverized, screened, and finally sacked by machine. The essential difference between this process and the others mentioned above lies in the fact that the material is first reduced to a fine condition before bleaching, thereby bringing the sulphuric acid intimately into contact with all portions of the barite.

In the manufacture of the white pigment lithopone, an intimate mixture of precipitated zinc sulphide and barium sulphate, barite is first reduced from the sulphate to the sulphide of barium, which is soluble, and then treated with a solution of zinc sulphate. The reducing of barite is effected by heating to bright redness a mixture of about four parts of crude barite and one part of a very low ash coal in a rotating furnace.[1] The coal acts as a reducing agent, and converts 60 to 70 per cent of the barite to barium sulphide, the remainder being converted to barium carbonate. A similar principle is employed in the initial stages of the production of other barium salts.

POSSIBLE VALUE OF THE BARITE OF THE CASTLE ISLANDS.

The barite described above is not of the highest grade, particularly for use as a pigment, and it will probably require a milling test to determine whether or not it may be possible, commercially, to remove the metallic sulphides and to bleach the color to a pure white. Simple laboratory experiments and comparison of the Alaska material with commercial grades of barite suggest that this may be possible. For example, tests by W. C. Wheeler and the writer show that washing and flotation tends to whiten the finely ground grayish-white powder. Further treatment with hot dilute sulphuric acid containing small quantities of sodium chloride and sodium nitrate bleaches the powder to a shade only slightly less white than that of precipitated barium sulphate or zinc oxide. These experiments are encouraging, and seem to indicate that with the aid of proper mechanical manipulation the process might be made commercially successful.

In the process of manufacture of lithopone and the various salts of barium where crude barite is fused with coal a slightly impure raw material would apparently react as well as one having a high

---

[1] Phalen, W. C., Production of barytes in 1911: U. S. Geol. Survey Mineral Resources, 1911, pt. 2, p. 966, 1912.

degree of purity, providing the impurities present were not in themselves objectionable. It is possible, therefore, that the Alaska barite is suitable for general chemical purposes.

Probably it would not be practicable to build and operate a barite mill in the vicinity of the deposit, but the raw material can certainly be quarried and loaded on barges very cheaply, and transported to Puget Sound or to San Francisco at low freight rates. The approaches to the Castle Islands, though not very deep, show, according to Coast and Geodetic Survey charts, from 5 to more than 30 fathoms of water. In the immediate vicinity of the islands the depth of the water is such that wharves could be built, and there is plenty of timber at hand suitable for this purpose. On the island of which the barite deposit is an outlier there is level space sufficient for the necessary buildings of a quarry camp. Quarrying of the deposit would evidently be very simple, as the material could be blasted from the face of the cliff and a large output obtained in a relatively short time. Over the top of the mass there is a bushy growth of spruce and cedar with little soil, and if this were stripped off at first the deposit would afford an unusually clean quarry.

PRODUCTION,[1] IMPORTS,[2] AND PRICES OF BARITE.

The production of crude barite in the United States in 1913 was 45,298 short tons, valued at $156,275. This represents the value of the crude material free on board at the mines, and gives an average price for the whole country of $3.45 a ton of 2,000 pounds. The average price in the southeastern Missouri district was $3.78 a ton. The imports of crude barite entered for consumption during 1913 amounted to 35,840 short tons, valued at $61,409, or $1.71 a ton, and of manufactured barite 5,463 short tons, valued at $38,155, or $6.98 a ton. Of these imports, 82 short tons of crude barite, valued at $144, or $1.76 a ton, and 601 short tons of manufactured barite, valued at $3,976, or $6.62 a ton, were entered at San Francisco, the only Pacific coast port which received any barite during 1913.

---

[1] Hill, J. M., The production of barytes in 1913: U. S. Geol. Survey Mineral Resources, 1913, pt. 2, pp. 165-166, 1914.

[2] Imports according to Bureau of Foreign and Domestic Commerce, Department of Commerce.

MINERAL DEPOSITS OF THE YAKATAGA DISTRICT.

By A. G. Maddren.

INTRODUCTION.

The Yakataga district, where gold placers have been mined and petroleum seepages and coal beds have been found, lies on the central Pacific seaboard of Alaska in front of the western part of the great St. Elias Range, whose crest line stands from 10,000 to 18,000 feet above sea level, within 30 to 40 miles of the ocean. The shore line, which forms the southern boundary of the district, follows approximately the sixtieth parallel of north latitude (Pl. IV, p. 130). The coastwise extent of the district from east to west is about 60 miles, from 141° 40′ to 143° 20′ west longitude, and at its opposite extremities it is delimited by two of the largest piedmont glaciers in Alaska. On the west is Bering Glacier, named for the discoverer of the country, and on the east Malaspina Glacier, named for one of the earlier explorers of this coast. Its inland boundary is ill defined, but it can be regarded as including the front range of the St. Elias Mountains, here termed the Robinson Mountains, whose main crest line lies 10 to 15 miles from the coast.

The region thus outlined contains about 1,000 square miles. Though its shore line was well known to prospectors, some of whom had journeyed far inland, the region had until 1913 been relatively little explored. Surveys of the coast line and inland as far as the petroleum seepages were made in 1898 and 1899 by J. L. McPherson in the interest of oil claimants. The resultant data have been embodied on various official maps. Mr. McPherson and Mr. F. H. Shepherd also made geologic observations in this district, which they did not publish themselves but generously turned over to members of the Survey, and these have been recorded in various official publications, as follows:

Eldridge, G. H., The coast from Lynn Canal to Prince William Sound. In Maps and descriptions of routes of exploration in Alaska in 1898: U. S. Geol. Survey Special Pub., p. 104, 1899.

Spurr, J. E., A reconnaissance in southwestern Alaska: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, p. 264, 1900.

Martin, G. C., Cape Yakataga placers: U. S. Geol. Survey Bull. 259, pp. 88–89, 1905.

Martin, G. C., Geology and mineral resources of the Controller Bay region, Alaska: U. S. Geol. Survey Bull. 335, pp. 26, 63, 114, 115, and 118, 1908.

The Yakutat Bay region and the slopes of St. Elias, lying 20 to 40 miles east of Yakataga, have long been a field of scientific exploration. A large number of publications relate to St. Elias, but few of them contain geologic data. The publications of I. C. Russell, however, are an exception, for his investigations in 1890 and 1891 did much to elucidate the stratigraphy of the St. Elias region as well as the glacial geology. Much additional information was obtained by R. S. Tarr, who in 1905 and 1906 made a comprehensive study of the glacial geology of this region, in the course of which he obtained much new information concerning the bedrock geology. The geology of the Controller Bay region, 60 miles to the west, has been studied in detail by G. C. Martin. Therefore, though the geology of the Yakataga district was until 1913 but little known, the region is flanked on both sides by areas that had been investigated. The principal reports dealing with these adjacent regions are listed below:

Russell, I. C., An expedition to Mount St. Elias: Nat. Geog. Mag., vol. 3, pp. 53-203, 1891.

Russell, I. C., Second expedition to Mount St. Elias: U. S. Geol. Survey Thirteenth Ann. Rept., pt. 2, pp. 1-92, 1893.

Filippo de Filippi, The ascent of Mount St. Elias by H. R. H. Prince Luigi Amedeo di Savoia, Duke of the Abruzzi, 1900.

Tarr, R. S., The Yakutat Bay region, Alaska: U. S. Geol. Survey Prof. Paper 64, 1909.

Tarr, R. S., and Martin, Lawrence, The earthquakes at Yakutat Bay, Alaska, in September, 1899: U. S. Geol. Survey Prof. Paper 69, 1912.

Martin, G. C., Geology and mineral resources of the Controller Bay region, Alaska: U. S. Geol. Survey Bull. 335, 1908.

About two months was employed in the field investigations on which this report is based. This time was devoted not only to a study of the geology and mineral resources but also to making a topographic exploratory survey of the area. Besides traversing the shore line the inland region was penetrated at several places for a distance of 5 to 25 miles. Heavy vegetation on lower slopes and ice covering at higher altitudes masks much of the bedrock, and this fact, combined with the physical obstacles to travel indigenous to a region of glacial streams, strong relief, and without trails, made the geologic observations difficult. The conclusions reached must, therefore, be regarded as tentative. Only the salient features of the geology and mineral resources will here be set forth, the more elaborate discussions being reserved for another report, now in preparation, that will be more fully illustrated. The writer was fortunate in having the efficient assistance of E. O. Blades throughout the field work. He is also under obligations to the prospectors and miners of the district for information and aid given in various ways. Special acknowledgment should be made to Mr. V. Blodgett, who furnished valuable data about the White River gold placers.

TOPOGRAPHY.

RELIEF.

The main crest line of the St. Elias Range, though unexplored, probably lies 30 to 40 miles inland from the beach at Yakataga. Between these mountains and the sea lies another range forming a westward extension of what Russell[1] termed in the St. Elias region the "Robinson Hills." As this highland mass is rugged, with peaks from 5,000 to 10,000 feet high, it is more properly designated the Robinson Mountains and forms the front range of the St. Elias chain. The two ranges are separated by a field of ice that is tributary to the Bering and Guyot glaciers. The Robinson Mountains form a highland belt extending from the vicinity of Icy Bay on the east to Bering Glacier on the west.

Both ends of the range terminate in areas of lesser relief which are deeply buried in great piedmont glaciers. These glaciers are fed by the ice and snow fields of the St. Elias Range and extend practically to the coast. They form an ice barrier that is nowhere less than 10 miles broad and many miles in aggregate length, which practically isolates the Yakataga district on the west, north, and east. Only a narrow strip of unstable glacial outwash coastal plain, 2 to 5 miles wide and 30 miles long, extending westward between the southern edge of Bering Glacier and the ocean to Controller Bay district, affords any land connection whatever with contiguous areas. All approaches to the district from any other overland direction are barred by wide ice fields.

The Robinson Mountains are made up of three parallel ridges whose trend is a few degrees north of west, and thus slightly oblique to the coast line. The first or southernmost of these mountain ridges fronts the ocean, in close proximity to the shore, from Icy Bay to Yakataga Reef, its western terminus. The second and third successively higher inland ridges are not so distinctly separated from each other as the first or coastal ridge is from them, and both these inland ridges extend farther west than the front one. Here they form the mountain abutments to the eastern margin of Bering Glacier. In the far eastern part of the district all three of these ridges of the Robinson Mountains are high and merge into one mountain mass, forming a highland area whose general altitude is about 5,000 or 6,000 feet above sea level and whose summits rise to elevations of 7,000 to 9,000 feet. Westward from this highland area these mountain ridges become more separated and distinct, especially the southernmost and the one next north from it, and two valley basins of considerable

---

[1] Russell, I. C., Second expedition to Mount St. Elias: U. S. Geol. Survey Thirteenth Ann. Rept., pt. 2, Pl. IV and p. 17, 1893.

length and breadth lie between them. The easternmost of these valleys is 7 or 8 miles in length from east to west and is largely occupied by a glacier named White River Glacier from the stream that drains it. Westward from this valley basin is another, the largest and most open one in the district, about 20 miles long and 5 to 7 miles broad, that comprises the general continuation, in this direction, of the depression between the coastal and inland mountain ridges. Large glaciers occupy the head of this valley, but its lower part is free from ice. It is drained by Yakataga River, a large glacial stream about 10 miles long, which discharges into the ocean about 2 miles west from Yakataga Reef.

There is a gradual lowering of these mountain ridges and summits from east to west. Thus the summits on the coastal front ridge descend from altitudes of 5,000 to 6,000 feet on the east to 2,000 feet immediately back of Yakataga Reef through a distance of about 30 miles. The peaks along the second ridge descend from about 7,500 to 3,000 feet through a distance of about 35 miles from east to west, and those which mark the third and highest ridge descend in altitude from about 9,000 to 4,000 feet in the same direction along a distance of about 40 miles. With the decrease in elevation of the Robinson Mountains from east to west their crests become somewhat less rugged in form, their slopes more gentle, and in general they appear more openly spaced, with broader valley areas between them.

From Yakataga Reef eastward for about 35 miles the base of the seaward slopes of the southernmost ridge of Robinson Mountains stands within one-half to 1 mile of the beach. The present beach along this part of the coast is narrow, ranging from 200 to 600 feet in width, and its inner limit is marked by a cut bank from 5 to 50 feet in height that is formed by the undermining and consequent caving caused by the storm surges at high-tide level. West of Yakataga Reef the coastal plain expands to a width of 5 miles and more. Inland the coastal plain merges with the broader valleys. The coastal plain is entirely built of unconsolidated outwash sediments from these valleys, all of which carry streams derived from glaciers.

COAST LINE.

From Cape Suckling on the west to Icy Bay on the east the strand line is remarkably even. With the exception of two small rocky reefs there are no irregularities in the shore line of the Yakataga district, its immediate strand being wholly formed of a direct and regular ocean beach of sands and gravels without any bays or inlets. Although high tides back up into the mouths of several of the larger glacial rivers of the district and form shallow lagoons of some extent, none of these lagoons deflect the regular direction of the strand line, which is built across their entrances in the form of spits and shallow surf-bound bars. Cape Suckling is a rocky headland from which a ridge about 1,200 feet high extends inland for about 10 miles to the Bering Glacier. This ridge separates a lowland surrounding Controller Bay from the coastal plain stretching eastward along the shore to Yakataga.

The larger of the two small areas of rocky shore is named Yakataga Reef (Cape Yakataga) and the other Umbrella Reef. Yakataga Reef is situated about midway of the coastal length of the district, and the rocks forming it extend south from the beach into the ocean about half a mile. It is essentially a wave-cut rock platform about 1,500 feet wide, whose surface stands at the level of mean tide, above which rise two ridges of harder rock that flank its east and west margins. Portions of these ridges stand 10 to 20 feet above the general surface of the platform.

Umbrella Reef lies about 15 miles east of Yakataga Reef. It is a narrow ledge of rock about one-eighth of a mile wide and three-fourths of a mile long that lies parallel with the shore. Little of it stands above high-tide level; consequently for the most part it is surf swept, except at the lowest stages of tide in calm weather.

Icy Bay is an indentation of the coast line at the eastern end of the district. Its entrance is marked by low sand spits, beyond which it extends inland about 10 miles and is about 7 miles wide. Guyot Glacier discharges into the head of the bay, which has been formed recently by the retreat of this glacier. Its availability as a port is discussed on pages 150–151.

DRAINAGE.

Much of the precipitation in the mountains occurs in the form of snow and is carried to lower altitudes by the glaciers. East of Yakataga Reef numerous small watercourses drain directly into the sea, the mountainous parts of their valleys being rather narrow defiles. Of these streams White River is the largest. This river springs from a glacier of the same name, flows westward for about 5 miles, then bends sharply to the south and reaches the sea about 10 miles from its source. Its lower valley is a narrow canyon that has been incised in an old valley floor, now left as a series of gravel-covered benches. White River is important because its gravels contain gold placers. Certain recent changes of drainage of this river will be described in the account of gold placers which is given on page 137.

The drainage west of Yakataga Reef is carried to the sea by several rivers of considerable size. Of these Yakataga River, which rises in a glacier of the same name, flows through a broad valley with rather gentle slope, though broken by gravel benches, for about 10 miles, where it debouches on the coastal plain. The next stream to the west is Duktoth River, which also has a glacial source, but whose headwaters have not been surveyed. The drainage of the western end of the Robinson Mountains is carried by Kaliek River, which has a southeasterly course and empties into a lagoon about 15 miles west of Yakataga River. Between this river and Cape Suckling the many small streams which drain the southern margin of the Bering Glacier empty into the sea.

CLIMATE.

The Yakataga region falls into two climatic provinces. Most of the area standing above 3,000 or 4,000 feet may be said to have an alpine-boreal climate, but the climate of the coastal lowland is temperate. Evidence of this alpine-boreal climate is found in the widespread and, over large areas, almost continuous development of actual glaciation or at least strong incipient glacial conditions in the form of perpetual névé fields. A probable estimate is that half of this part of the Pacific seaboard is now under actual glacial conditions. It may be remarked that these conditions extend below the level of 3,000 feet over considerable areas at many places, especially just east and west from Yakataga district, where the expansive Malaspina and Bering glaciers extend practically to the ocean.

Throughout the district precipitation is excessive. Practically all of it occurs in the form of snow in the higher mountains and chiefly in the form of rain along the narrow coastal plain. These two forms of precipitation dominate their respective zones throughout the year, and both their vertical and horizontal distribution is maintained within quite stable limits. Thus precipitation in the form of rain is rare above an elevation of 5,000 feet, and below that altitude snow falls only during the coldest winter months. The lower limit of perpetual snow is probably a thousand feet below this altitude on many parts of the inland slopes.

There are no meteorologic records for any part of the district. The nearest station is Katalla, where observations of two years indicate a total precipitation of 125 inches. It is safe to assume that at Yakataga the total precipitation is at least 100 inches. This amount is believed to be the minimum annual average for many localities, and in some parts of the province an annual precipitation of 150 to nearly 200 inches probably occurs. During the winter months much of the precipitation in the coast zone occurs in the form of damp snow and sleet. As a rule October is the month of greatest rainfall for the year, and January and February probably have the greatest number of clear days.

The coldest temperatures along the immediate coast are about zero (Fahrenheit), but inland a few miles it is often 10° or 15° colder, especially in the vicinity of large glaciers. Ponds and lakes in the coastal plain freeze permanently late in December, and the larger streams freeze and thaw alternately throughout the winter months.

There is practically no freezing of the ocean water, except occasionally along the beach between tide levels, during extremely cold snaps, and in the shallow brackish tidal estuaries or embayments on the outer margin of the coastal plain. From October to April the average maximum temperature is about 45°, the average minimum about 10°, and the average of monthly means about 30°. During this part of the year there are more distinctly clear days than during the summer, but the average precipitation is about the same. From April to October there are few wholly clear sunny days, most of the days being cloudy or foggy and more than half of them rainy. The precipitation for this period is heavy, amounting to over 50 inches of rainfall. Few of the clear summer days may be considered hot, although the maximum temperature may occasionally rise to possibly 80° for short intervals, during which the great humidity produces a sultry effect if the air is calm. The average maximum summer temperature of this coast zone from April to October is about 70°, the average minimum about 35°, and the average of monthly means for this period about 50°.

VEGETATION.

In the coastal belt, especially below the altitude of 2,500 feet, there is a heavy growth of coniferous trees and deciduous brush wherever the lower slopes, valley bottoms, and coastal plain are of stable character; that is, where the slopes are not so steep as to consist of bare bedrock or rock slides and where the flatlands are of sufficient age for vegetation to have gained a foothold. In favorable localities, both on the coastal plain and along the base of the mountains, where there is good soil and protection from cold winds and flooding by the silt-charged glacial streams, the growth of coniferous trees attains the standing of a forest in size, number, and vigor of individuals. Because of the generally unfavorable conditions for the accumulation of good soil the amount of such timber in Yakataga district is small and scattered in widely separated localities.

Sitka spruce and western hemlock are the chief forest trees. Spruce is usually dominant on the coastal plains and along the broader valley bottoms, where individuals commonly attain basal diameters of 5 or 6 feet and heights of 80 to 125 feet. Hemlock is most abundant on the mountain slopes, especially toward timber line. A few yellow cedar or Alaska cypress trees also are present in the Yakataga district, and large cottonwood trees form considerable groves along open parts of the coastal plain, especially along the moist bars of the larger streams.

Sitka alder, willows, salmonberry, and blueberry comprise the principal brush growth of the district, especially where tree growth is absent or sparse and about the borders of heavily timbered areas. Within the shade of heavy timber growth these brush plants are more or less abundant, but in such situations the prickly devil's-club is most commonly found. A thick growth of rank bracken ferns also occurs wherever the ground is constantly moist, especially in the shade of forest growth. Some sedge grass grows in the lowlands in scattered patches and also a little redtop. These grasses have been cut for hay, though they are of indifferent quality and difficult to cure because of the wet summers. The wild strawberry grows abundantly along many parts of the coastal plain and seems to favor particularly warm sandy soil, such as accumulations about dune tracts.

GEOLOGY.

GENERAL FEATURES.

Three geologic provinces can be recognized in the Yakataga district. First, there is the main St. Elias Range, probably made up of closely folded, more or less metamorphosed rocks, together with igneous intrusives. That part of the St. Elias Range lying north of the Yakataga district is unexplored, but its geology is inferred from what is known of the Yakutat and Controller Bay region. These oldest rocks will not here be further considered. The second province includes the Robinson Mountains, and these are built up of Tertiary and some Pleistocene sediments. This great series of rocks contains fossils, assigned by W. H. Dall to formations ranging in age from Oligocene to Pleistocene and Recent, besides which there is a coal-bearing formation believed to be of Eocene age. These rocks are thrown into a series of folds, in part open, in part closely compressed, whose axes trend about N. 70° W. In certain localities there has been pronounced faulting. No igneous rocks have been found in this series. A third province includes the coastal plain, built up largely of glacial overwash gravels. This report is chiefly concerned with the Tertiary and Quaternary deposits, which contain the known mineral resources of the region.

The Robinson Mountain section comprises a great variety of deposits, most of which are of marine origin. Shales, fine and gritty sandstones, shales and sandstones containing scattered pebbles, pebble conglomerates with a considerable proportion of shaly and sandy matrix, and pebble and cobble conglomerates with little finer-grained matrix comprise all the strata in some form of development. Sandstones form the most massive and shales the thickest and most consistent members of the section. The only limestones observed are thin bands in some of the thicker shale members, several of which are somewhat calcareous throughout several hundred feet of beds, but even in these sandy and gravelly layers are numerous. In general calcareous and sandy shales are more abundant in the lower part of the section, but conglomerate and sandstone beds are also developed there. Thick shale members are likewise present toward the top of the section and thinner layers of shale are interbedded with many of the conglomerates. Some of the pebble beds have a shale matrix containing marine shells.

So far as is now known, with the exception of the bowlder-bearing Pleistocene terrane these variously textured beds of marine sediments can not be arranged into definite lithologic groups. Finer and coarser phases are more or less repeated throughout the thickness of 7,000 or 8,000 feet by vertical alterations and in some localities along the same bed. This horizontal change is most striking in conglomerate beds, which appear to be lenses. Some of the conglomerate members do indicate erosional unconformity, but their development as stratigraphic horizon markers is not persistent for any distance.

The following table is a provisional attempt to subdivide these rocks. It may require some modification when the geologic notes have been more exhaustively studied.

Provisional stratigraphic sequence in Robinson Mountains.

Age.	Lithology.	Approximate thickness.	Remarks.
		Feet.	
Pleistocene....	Bowlder-bearing sandstone and shales.	2,000-4,000	This is the same formation described by Russell as the "Piunacle system." Contains Pleistocene fossils.
Pliocene.......	Shales and flaggy sandstones and conglomerates.	2,000+	Contains some marine Pliocene fossils.
Upper Miocene	Buff-colored sandstone and shales with beds of conglomerate.	1,000-1,500	A bed of sandstone with some shale about 500 feet thick is included, which contains fossils identified by W. H. Dall as species occurring in the Empire formation (Miocene) of Oregon.
Miocene and Oligocene.	Sandstones and shales and some thin beds of conglomerate. Calcareous shales, thin limestone beds, and some thin beds of conglomerate.	3,000	Contain Miocene and Oligocene marine fossils.
Eocene........	Gray fine-grained arkose and black shale and some beds of coal.	2,000±	Probably the equivalent of Kushtaka formation of Controller Bay.

The age assignments in the above table are by no means definitely determined. Though many of the beds carry invertebrate fossils, these are in part so crushed as to be difficult to determine. Moreover, the conditions of the field work did not permit making and transporting large collections. No doubt detailed stratigraphic work and large collections would account for some apparent inconsistencies in the age determinations of certain beds, as noted in the appended list of fossils. It should also be noted that some of the fossils were float material. The determinations of the fossils in the list were made by W. H. Dall.

6678. Bluff at Camp Gulch, northwest side of Icy Bay, about 4 miles northeast of Big River:

Venericardia subtenta Conrad. Miocene.

Tellina (Angulus) cf. albaria Conrad. Miocene.

6679. Float at foot of bench bluffs about 3 miles southwest from west foot of Guyot Glacier, northwest of Icy Bay:
Terebratalia transversa Sowerby. Recent.

6680. Float from Big River outwash flats, probably out of Big River valley, northwest side of Icy Bay:
Priene pacifica Dall. Empire formation (Miocene), Coos Bay, Oreg. Purisima formation, California, upper or Pliocene part.

6681. Float from mouth of Johnston Creek:
Cardium cf. coosense Dall. Miocene.

6682. Float from Johnston Creek below oil seepage:
Mya truncata Linné (?). Recent. Protothaca sp. indet.

6683. Upper Johnston Creek within one-fourth mile of glacier, from angular talus blocks in creek bed:
Spisula precursor Dall. Miocene.
Venericardia castor Dall? Miocene.
Polinices galianoi Dall. Miocene, Pliocene. Astoria, Coos Bay, Oreg.

6684. Johnston Creek, from bluff on west bank about one-fourth mile below glacier and about three-fourths of a mile above oil seepage:
Nucula sp. cf. townsendi Dall. Miocene.
Crenella or Cardium sp.

6685. Bed of Poule Creek, from a spherical concretionary cobble:
Aturia angustata Conrad. Oligocene or lowest Miocene. Astoria, Oreg.

6686. Umbrella Reef, about one-half mile east of mouth of Lawrence Creek, at mean low-tide level:
Chrysodomus oncodes Dall. Recent.

6687. Float from bed of Lawrence Creek near mouth:
Spisula precursor Dall. Miocene.

6688. Float bowlder from bed of Lawrence Creek near mouth:
Spisula precursor Dall. Miocene.
Cardium cf. coosense Dall. Miocene. Coos Bay, Oreg.
Cardium cf. ciliatum Fabricius. Recent.
Fusinus corpulentus Conrad. Miocene. Astoria, Oreg.

6689. Float along bed of Lawrence Creek between foothill entrance to gorge and Fossil Creek:
Priene pacifica Dall. Miocene and Pliocene.
Chrysodomus sp. indet.
Polinices galianoi Dall. Miocene.
Dentalium cf. conradi Dall. Miocene.
Venericardia cf. subtenta Conrad Miocene.
Cardium cf. meekianum Gabb. Miocene.

6690. Float from bed of Lawrence Creek one-fourth mile below mouth of Fossil Creek:
Cardium cf. ciliatum Fabricius. Recent.
Indeterminable bivalve.

6691. Exposures of mouth of Fossil Creek, tributary to Lawrence Creek:
Amauropsis oregonensis Dall. Miocene.
Polinices galianoi Dall. Miocene.
Dentalium cf. conradi Dall. Miocene.
Cardium sp. indet.
Protocardia cf. richardsonii Whiteaves. Recent.

6692. From talus near source of Fossil Creek, derived from bedrock:
Priscofusus geniculus Conrad. Miocene.
Eudolium petrosum Conrad. Miocene.
"Cerithium"? mediale Conrad. Miocene.
Amauropsis oregonensis Dall. Miocene.

Spisula precursor Dall. Miocene.
Phacoides acutilineatus Conrad. Miocene.
Glycymeris cf. gabbi Dall. Younger Miocene.
Tellina (Angelus?) cf. arragonia Dall. Miocene.
Cardium cf. ciliatum Fabricius. Recent.
Thyasira? sp.

6693. Bluff on south bank of White River one-half mile below foot of glacier:
Pecten propatulus Conrad. Miocene.

6694. Mouth of large gulch on south slope of White River valley at foot of glacier; from talus but nearly in place:
Pecten parmeleei Dall. Pliocene. California.
Phacoides acutilineatus Conrad. Miocene.
Cardium sp. indet.
Acila conradi Meek.
Mya truncata Linné. Recent. Macoma sp.
Turritella cf. oregonensis Conrad. Miocene.
Polinices cf. galianoi Dall. Miocene.
Chrysodomus cf. ithius Dall. Recent.
Pleurotoma cf. cammani Dall. Miocene.
Fusinus cf. coosensis Dall. Miocene. Coos Bay, Oreg.
Venericardia crassidens Brodrip and Sowerby. Recent.
Yoldia impressa Conrad. Miocene.
Cancellaria n. sp.
Corbula? sp. indet.

6695. From sandy shale at intake tunnel of the White River Mining Co.'s flume, North Fork of White River:
Pecten purisimaensis Arnold. Pliocene.
Leda cf. minuta Fabricius. Recent.
Mya truncata Linné. Recent.
Thyasira? sp.
Cardium cf. decoratum Grewingk. Pleistocene.
Lysonia sp.
Lepton? sp. ind.
Periploma sp. Recent (?)

6696. One-fourth mile up North Fork of White River above intake tunnel of White River Mining Co.'s flume.
Leda fossa Baird. Recent.
Tellina cf. arctata Conrad. Miocene.
Cardium cf. coosense Dall. Miocene.
Mya truncata Linné. Recent.
Chione securis Shumard. Miocene (Empire formation). Oregon.

6697. Talus material (recent slide) from south face of Island Mountain, north side of main lobe of White River Glacier:
Mya truncata Linné. Recent.
Acila conradi Meek. Miocene.
Chione securis Shumard. Miocene.

6698. Yakataga Reef, shaly and sandy layers just above a massive sandstone member:
Rhynchonella psittacea Gmelin. Recent.
Terebratalia transversa Sowerby. Recent.
Laqueus californicus Koch. Recent.
Astrangia sp.
Gastropod, indeterminable.

Marcia oregonensis Conrad. Miocene to recent.

6701. Cape Suckling, near Controller Bay:
Wood with Xylotrya borings.
Fusinus sp. (fragment).
Marsia oregonensis Conrad. Miocene to Recent
Venus cf. parapodema Dall. Miocene.

EOCENE ROCKS.

The area believed to be occupied by sediments a
Eocene lies in the northern and least accessible part
Therefore but few field observations were made in t
far as known it is made up of fine-grained arkoses or a
black and gray shales and contains some beds of coal.
probably predominate over the shale. Though no acc
tions in thickness were obtained the entire Eocene s
measures 2,000 feet. These coal measures are belie
the northern part of the district. The approximate so
ary is indicated on the accompanying map (Pl. IV).
boundary is a fault line along which the coal measu
thrust up over the younger Pliocene sediments.
boundary of the formation lies in the unsurveyed
district.

No fossils were obtained from these Eocene rocks.
however, a strong lithologic similarity to the Kushtak
Controller Bay region[1] to the west, with which they
The Kushtaka carries fossil plants, which the recent stu
Hollick have shown to be of Kenai age (Eocene).

REGION.

marine invertebrates, indicates that these beds are either Oligocene or lower Miocene.

These beds are succeeded by a great series of sandstones and shales with some beds of conglomerate, which goes to make up the lower part of the ridge separating the White River valley from the coastal plain and also occurs to the west of the White River valley and near Icy Bay. Similar rocks are found in the second ridge from the coast, separating the valley of White River from that of Yakataga River. At several localities marine invertebrates were found in association with these beds, which led to their provisional assignment to the Miocene.

UPPER MIOCENE AND PLIOCENE ROCKS.

About 1,000 to 1,500 feet of buff-colored sandstone occurs in the upper part of the ridge lying between the coast and White River valley, and similar rocks occur in the two ridges to the westward. In this sequence is included a sandstone member that carries some shale, in which marine fossils were found which were identified by Mr. Dall as species occurring in the Empire formation of Oregon.

This sandstone is succeeded by a great series of buff-colored sandstones and shales, with some conglomerate beds more than 2,000 feet in thickness. These rocks form the ridge between the valleys of White and Yakataga rivers, and also occur in the next ridge to the north, where they are overlain by the Eocene coal measures, brought up by a great thrust fault. Some of these beds carry fossils, on the basis of which the entire series has been provisionally referred to the Pliocene.

PLEISTOCENE DEPOSITS.

The post-Eocene Tertiary rocks that have been described are essentially shallow marine deposits. In Pleistocene time the conditions changed, for the deposits of that epoch in the Yakataga region show the effect of glaciation. These Pleistocene beds constitute a remarkable terrane, whose thickness in the Robinson Mountains is at least 2,000 feet, but may be as much as 4,000 feet, according to local development along its strike. In places this terrane, as now exposed, may be only 1,000 feet thick, but this is probably due to the removal of part of its original thickness by erosion since its uplift into the mountains. This upper part of the Robinson Mountain section is, without doubt, Russell's "Pinnacle system," described[1] by him as occurring in the Chaix Hills and Pinnacle Pass, eastward from Robinson Mountains along the inner border of the Malaspina Glacier. His descriptions of its lithologic character, which is the most distinguishing feature of the

---

[1] Russell, I. C., An expedition to Mount St. Elias: Nat. Geog. Mag., vol. 3, pp. 170-178, 1891; also Second expedition to Mount St. Elias: U. S. Geol. Survey Thirteenth Ann. Rept., pt. 2, pp. 24-26, 1893.

formation, correspond with its general development in the Robinson Mountains, and the marine fossils he collected from the Pinnacle Pass and Chaix Hills sections also agree faunally with those obtained from the section in Robinson Mountains.

The Pleistocene of the Robinson Mountains section may be briefly described as comprising a thickness of 2,000 to 4,000 feet of massively bedded marine shales and sandstones containing a great number of large and moderate-sized bowlders of granite, greenstone, gneiss, schist, and crystalline limestone of glacial derivation, which apparently have been dropped without arrangement or assortment of any kind from icebergs given off into the ocean by tidal glaciers. These bowlders are embedded in a scattered manner throughout several thousand feet of silty sandstones and shales. This formation occurs at Umbrella Reef on the coast and also in the ridge west of White River valley. Though no evidence of a stratigraphic break was observed between the Pleistocene and the underlying Pliocene, an unconformity might be suspected from the change of physical conditions.

STRUCTURE.

Nothing is known of the structure of the main St. Elias Range. The Robinson Mountains consist, so far as determined, of a series of folds whose axes trend about N. 70° W. A closely compressed fold is marked by the minor valleys along which the petroleum seepages are located. This anticline pitches to the west, its nose being at Yakataga Reef. The northern limb of this anticline includes the rocks west of the White River valley, beyond which there is a syncline. The anticlinal fold is marked by the broad ridge south of Yakataga Valley, and the valley itself occupies a synclinal trough. The next highland mass to the north is anticlinal. There is a great thrust fault along the western limb of this anticline, which has thrust the Eocene over other sediments which are probably Pliocene. These structures are believed to dominate throughout the area, though the possibility of the presence of other extensive faults is not excluded.

The striking tectonic feature exhibited by the district is the fact that the deformation is so recent. Pleistocene beds of glaciofluviatile origin are involved in this folding. Moreover, the topography is largely structural, many of the valleys occupying synclines and the ridges anticlines. The only striking exception to this rule is the erosion along the crest of the first anticline north of the coast

MINERAL RESOURCES.

The known mineral resources of the Yakataga district are placer gold, coal, and petroleum. Gold mining has been carried on in a small way since about 1899. The auriferous beach sands were probably known to prospectors as early as 1897, and the petroleum seepages were discovered about the same time. Surveys have been made of petroleum claims and assessment work has been done, but there has been no drilling. Coal has long been known to be present in the less accessible inland parts of the district, but has received relatively little attention.

PLACER GOLD.

OCCURRENCE.

The developed gold deposits of the Yakataga district comprise beach placers and stream placers. It is known that the gravels of which the coastal plain is built are more or less auriferous, but these deposits have not yet been mined. Nearly all the gold thus far obtained has been recovered by beach mining, though some important developments of the stream placers of the White River valley are under way.

The auriferous area as now known stretches 15 or 20 miles along the coast, but its extent inland is not known except in the White River valley. It is therefore confined to the coastal slope of the southernmost ridge of the Robinson Mountains.

METHODS OF RECOVERY.

As stated above, gold was first found in the beach sands of Yakataga about 1897 or 1898. In 1899 several men began working the beach sands with rockers, amalgamating on copper plates or in the absence of these on silver coins. Mining of this simple character was continued for the next three years at various places along the beach. In 1903 an unsuccessful attempt was made to mine the beach sands with a 6-inch centrifugal pump, the plan being to lift the sand with the gold to boxes for washing and amalgamation. During the autumn of 1903 about 40 men mined the beach sands by hand, using rockers and long toms with copper plates. It is said all these workers did well, the lowest yield for each man being about $600 or $700 and that of a few as much as $2,000 or $3,000. Most of this mining was done along the 4 miles of beach east of Yakataga Reef.

After experience had been gained in recovering gold the rockers were abandoned and an enlarged and improved long tom or sluice box adopted. Copper plates and amalgamation were also discontinued, it being found that when sharp sands were washed not only the amalgam was scoured off and lost but the silver plating also was eroded from the copper plates. Canvas was first substituted for plates and then strips of blanket were substituted for canvas. Later tucks or plaits were sewed across the blankets. The saving of fine gold thus effected with blankets has proved far superior to that by the use of copper plates. The most convenient size for the blanket concentration boxes for hand shoveling is about 16 inches wide and 10 or 12 feet long.

About 300 men were in Yakataga district in 1904, which was the maximum in any one year. Since that time the number has dwindled greatly. In 1913 only about a dozen men engaged in beach mining resided in the district throughout the year.

Placer gold was found in the White River valley in 1902, and a little mining was done in the same year. About 1908 a small hydraulic plant was installed, and this has been operated when there was sufficient water. As will be shown below, this property is now being developed on a large scale.

PRODUCTION.

There are no records of the gold production, and estimates of the output by men who have engaged in mining differ greatly. The estimate of the value of the total gold output ranges from about $150,000 to over $350,000. It is impossible to harmonize the conflicting testimony on gold output. The writer is inclined to accept the lower figures as being nearly correct, and estimates based on these figures are presented in the following table. This table includes the silver production computed on the purity of the gold.

Estimates of gold and silver production from Yakataga district, 1899 to 1913.

	Gold.		Silver.	
	Fine ounces.	Value.	Fine ounces.	Value.
1899	96.75	$2,000	10	$6
1900	145.12+	3,000	16	10
1901	145.13−	3,000	16	10
1902	145.13+	3,000	16	8
1903	725.62−	15,000	80	43
1904	2,418.74	50,000	266	144
1905	1,451.25	30,000	160	98
1906	967.50	20,000	106	72
1907	725.63+	15,000	80	53
1908	967.50	20,000	106	56
1909	483.75	10,000	53	28
1910	483.75	10,000	53	29
1911	387.00	8,000	42	22
1912	435.38−	9,000	48	29
1913	193.50	4,000	21	13
	9,771.74	202,000	1,073	631

BEACH PLACERS.

The gold beach placers were originally distributed along the coast from about a mile west of Yakataga Reef to about a quarter of a mile east of Umbrella Reef, a distance of about 18 miles. Along this stretch the beach sands are still auriferous, though much of the richest placer ground has been mined out. The beach is steep and ranges from 200 to 300 feet in width at low tide. Its upper limit is marked by a scarp from 5 to 30 feet high that is cut into the outer margin of the coastal plain by storm-wave action. The base of this scarp is about 10 to 15 feet above mean high tide. The coastal plain has a width of about half a mile, except in its central part near White River, where it is fully a mile broad. It has the general configuration of a gently graded alluvial fan which extends up the White River valley. A mile from the beach this wide part of the coastal plain is fully 100 feet above sea level. To the east and west, where it is narrower, its inland border stands at an elevation of about 50 feet above sea level.

The surface action of the waves in cutting the margin of this coastal plain and the accompanying concentration of the heavier constituents in its sediments effected thereby, have produced the present beach placers. The gold-bearing beach sands are distributed with a variable degree of concentration along the present shore for a distance of about 8 miles to either side of the mouth of White River. On the east appreciable amounts of gold have been found only a short distance beyond Umbrella Reef, and on the west the beach sands yield nothing of value beyond the mouth of Yakataga River (Pl. IV). The richest concentrations of beach gold were found west of the mouth of White River. Before the beach was disturbed by mining the most continuous layers of gold-bearing sand were found along that part of the coast that extends 4 or 5 miles east of Yakataga Reef. The obstruction offered by this rocky reef to the general westward movement of the sand no doubt has had much to do with retarding a considerable portion of the heavier beach materials to the east of it. It is a significant fact that the gold which occurs in the beach just west of Yakataga Reef is considerably finer than that east of the reef. It is reported that the largest and heaviest beach gold is found within a mile or so of the mouth of White River, and that it becomes finer east and west from that locality. The beach adjacent to the mouth of White River is not favorable for mining, because that stream delivers considerable sand and silt to the ocean. This material is thrown up by the waves in such quantities as to cover the gold-bearing layers. The material itself is not sorted, and hence its gold content can not be profitably recovered. The covering of the beach gold with quantities of lighter top sands in which the fine gold is not concentrated to an appreciable degree is at times more or less characteristic of the whole length of the productive beach and is always present in some parts of the beach.

The gold placers that have been mined occur chiefly near the base of this escarpment but extend down the beach for different distances. As the gold is very fine it is carried farther down the beach in some places and concentrated at favorable spots. The auriferous sand occurs in irregular patches, many of them now mined being only a few square yards in extent and a few inches in thickness. When the district was first developed much larger areas of gold-bearing sand were found. The overburden in the present mining operations is in few places more than a foot in thickness, and much of the concentration is directly at the surface. There seems to be a little fine gold in all the beach sand. Some profitable mining is done by ground-sluicing the upper layer of sand at the margin of the beach near the scarp to a depth of 2 or 3 feet, thus concentrating the gold. The concentrates are then shoveled into the sluice box.

In the early days of mining there were probably well-defined layers of gold-bearing sand. Now the beach has been so torn up and so much of the gold taken out that it is difficult to determine the original character of the deposits.

The beach as a whole is thus undergoing a rather continuous process of natural concentration by the surf. Although this process of washing may be reducing certain parts of the beach sands to such a degree of concentration that fine gold is present in profitable quantities, other parts are receiving such quantities of unconcentrated material from the caving of the coastal plain scarp or from the surf sweepings of contiguous areas that the average tenor of a given number of cubic yards may be reduced far below the limit of profitable handling.

The periods and duration of violent storms in conjunction with the various stages of high and low tides, the difference in height of which ranges from about 4 to 14 feet, are the chief factors of beach concentration along the Yakataga coast. The best concentrations take place during the winter season, but often such concentrations are made along a certain part of the beach only to be dissipated before the gold can be recovered by the miners.

Bedrock is not exposed on the beach except at Yakataga and Umbrella reefs. It is reported by miners that the beach sands have been penetrated to depths of 17 feet and have been found to carry a little gold throughout that thickness. As the beach has a steep slope and it is not known where this hole was sunk, no measure of thickness is revealed by this information. Some holes put down 10 to 15 feet near the upper margin of the beach reached a layer of fine gravel, locally termed "bedrock" by the miners.

Most of the beach gold is bright colored, flakey, and very fine. A flake as large as the head of a pin is exceptionally large. The largest flakes have a value of about 4 cents. There is an unverified report that a gold nugget worth $43 was found on Umbrella Reef. Prospectors report that the gold mined west of Yakataga Reef is not flakey but granular, and that here the percentage of magnetite is greater than to the east.

The most common mineral in the heavy sand is garnet. This forms the so-called ruby sand of the miner, and, together with a small percentage of black magnetite, furnishes a guide in determining the profitable parts of the beach to work. A few small nuggets of native copper are reported to have been found near White River, but no trace of platinum is known to occur in the beach sands, although some heavy zircon sands have been supposed, mistakenly, to contain that metal.

The average fineness of the beach gold is about 0.880, and it contains about 11 per cent of silver. The commercial value of the native gold is about $18.50 an ounce.

The immediate source of the beach gold, as already shown, is in the gravels of the coastal plain. In these gravels the gold appears to be disseminated to such an extent that it can not be mined by methods now in use. The possibility of older beach lines existing in this gravel plain is not excluded, but the reports of the finding of such by prospectors are unverified.

The evidence in hand indicates that the coastal-plain sediments are largely fluvioglacial deposits of White River and possibly of some of the smaller streams. White River has changed its course in recent time, its mouth formerly being much farther west than it is now. The deposition of these coastal-plain sediments took place when the volume of White River and other streams was much greater than now and the waters were more heavily charged with sediments. A coastal plain was thus built, which extended far beyond the present beach line, but how far is not known. There is some evidence that the surf has eaten away 100 or 200 yards of the beach since mining first began in 1899. By this successive inland transgression of the sea, and hence of the strand line, new sections of the coastal-plain gravels have become exposed and their gold content concentrated in the beach to form placers. Such action had long been in progress when mining first began, and hence the first comers reaped the result of this surf concentration of a considerable period of time. The present miners, on the other hand, are dependent for the most part on the concentration now being effected by heavy storms.

It remains to consider the probability of gold placers being present in the coastal-plain sediments. In the absence of the results of actual tests of these sediments, such as may be obtained only by means of a carefully conducted and comprehensive series of drill holes or shafts, no definite statements are possible. There may be old beach lines of concentration similar to the present beach, but it is not thought to be probable, as there is no evidence of a scarp caused by the coastal plain having been eroded back by wave cutting previous to the present one. It is not impossible, however, that some shore-line concentration by transient advance took place along the margin of the coastal plain as it was built out and that these old beaches have been successively buried beneath the advancing sediments of which the coastal plain is constructed. It is not thought that such concentrations were as thorough and consequently as rich as the present beach. It is by no means certain that the entire coastal plain is made of the same material as that on the beach. There may have been an outer bar of sand and gravel back of which fine silts accumulated in lagoons deposited by streams too sluggish to carry gold.

The glaciofluvial nature of the coastal-plain sediments as a whole, and especially in the vicinity of White River, may be used as an argument that all the deposits contain some fine gold more or less uniformly scattered throughout the mass. If prospecting should determine this to be so and that the average gold content of the sediments is sufficient to be profitable, the mining of this deposit on a large scale may prove successful. Such an enterprise should not be entered upon, however, until the ground has been tested. If gold placers are found, they will probably only be such as can be exploited by dredges. The conditions for hydraulic mining in the coastal plain are unfavorable, for the water supply is scant unless long ditches are built. So far as known there is no bedrock to work to, and the sediments are so located as to offer no dump for tailings without elevating sluice boxes. If dredging ground is discovered, the operation is also confronted with difficulties, the most serious being the presence of a large quantity of driftwood in the coastal-plain sediments, including sticks of timber a hundred feet in length. The lack of information regarding depth to bedrock is another deterring factor for a dredging enterprise. On the other hand, the bedrock, if present, will probably be soft. The presence of large glacial bowlders is also not excluded, though such have not been observed. The unfavorable conditions of transportation will be considered below. The favorable conditions for dredging are that operations can be continuous probably throughout the year—certainly for eight or nine months—and that there is excellent timber at hand both for building and for fuel. In addition to the wood, oil is also available for fuel.

STREAM PLACERS.

The known stream-placer gold is confined, so far as known, to White River valley. This river drains a large glacial ice tongue of the same name and discharges into the sea about 7 miles east of Yakataga Reef.

The bedrock formations that now outcrop about the White River basin indicate that it was incised in the marine bowlder-bearing Pleistocene formation and the succeeding fluviatile deposits. Considerable remnants of the fluviatile sediments are still present in the bedrock of the basin in intimate association with the older marine

Pleistocene that here contains an abundance of marine shells. The exposures of these Pleistocene fluviatile terranes indicate a thickness of 400 or 500 feet, much of the material being erratic.

The Recent gravels of the White River basin comprise those of the present stream and those occurring as a bench deposit about the present water level. Both deposits carry alluvial gold, but only the bench placers have been mined. The concentration of the placer gold is probably greater in the narrow bed of the present stream than it is in the benches. To recover this gold would, however, necessitate the turning of the entire river from its present bed.

In the lower part of the White River valley there are only a few remnants of older valley floors, and this material is barren. Some fairly wide benches are developed in the upper valley, especially in that part of its course which lies within a mile of the glacier. The rock-cut benches are best developed along the right side of the valley. Here the channel of the river has dissected the old valley floor to a depth of about 15 feet above average stream level at the upper end of the bench, and to about 35 or 40 feet at the downstream end. This indicates that the present grade of the river is steeper, by 20 or 25 feet in a distance of about 1½ miles, than it was before it dissected its present channel below the grade of the benches, the remnants of an older valley floor. The following notes are largely based on memoranda furnished by Mr. V. Blodgett, who has charge of the mining operations at this locality.

The most extensive of these benches now lies in three somewhat detached strips. In upstream order these strips may be conveniently designated Nos. 1, 2, and 3 for the purpose of separate descriptions, although they were all planated by the same stage of erosion and had their unconsolidated covering of gold-bearing gravels deposited on them by the same stage of stream concentration. Benches Nos. 2 and 3 are virtually coextensive, being separated only by Willow Creek, a tributary stream. This stream has cut away about 1,000 feet of the bench and thus removed a considerable quantity of the gold-bearing gravels. The upper end of bench No. 1 is separated from the downstream end of bench No. 2 for a distance of about a quarter of a mile by a bedrock channel which the river is now making at the base of a projecting spur of the valley slope.

Bench No. 1 has an exposed face of gravel from 15 to 18 feet thick that extends along the river about 900 feet. These gravels rest on top of a rock-cut bench whose surface is 35 to 40 feet above the present grade of the stream. The width of the bench back from the river bank ranges from 300 to 500 feet and even more, but the bedrock slope of the valley rises steeply. Most likely the gravel covering of this bench becomes considerably thinner toward the valley wall. The whole surface of the bench is heavily overgrown with timber and brush.

The gravels in this bench are much smaller in average size, more typically stream assorted, and contain fewer cobbles and bowlders than those in the benches farther upstream. Their higher position above the level of the river affords a better dump for tailings. If ample water is available they should be much more easily hydraulicked than the upstream benches. Their successful exploitation will depend chiefly on whether their gold content is uniformly distributed throughout the deposit, unless parts of the deposit are much richer than is supposed. In view of their glaciofluvial origin it is probable that their gold content is not all concentrated on bedrock, as generally occurs with less vigorously deposited stream alluvium.

Bench No. 2 is a little more than a quarter of a mile long and extends back from the river in some places more than 500 feet. The bedrock surface on which the gravels rest has an average elevation above the river of about 25 feet and thus a fair dump for tailings is afforded. The thickness of the gravels ranges from about 5 to 15 feet, somewhat over half of the gravel deposit being about 15 feet thick. It contains a much larger quantity of coarser material and a great many more large bowlders than the bench described above.

Bench No. 3 is narrower than the two downstream benches previously described. It extends from the mouth of Willow Creek upstream for about one-third of a mile to a point where the narrow stream-eroded part of White River valley opens out into a broad basin near the glacier. This bench, 100 to 200 feet wide, swings around the southeast flank of a rounded knoll of bedrock a couple of hundred feet in altitude that now stands isolated in the valley floor. The knoll appears to be the end of a spur that has been cut off from the mountain slope which bounds the basin on the southeast. The rim of bedrock which marks the surface of the former bedrock floor of this part of the valley stands about 15 feet above the present river level, hence there is not so much dumping room for tailings along this bench as there is for the downstream benches. The unconsolidated bench materials of bowlder, cobbles, and gravel have an average thickness of about 10 feet. Much of the material of these deposits has been already sluiced off. At least 40 and possibly 50 per cent of this deposit is made up of very large cobbles and big bowlders which weigh from a few hundred pounds up to many tons. Small Pelton wheel derricks have been employed to move these bowlders out of the working cuts in the mining operations that have been conducted on this bench in the past, but these do not seem adequate for rapid work, such as is contemplated. Blasting and aerial cables operated by steam hoists probably will have to be used in removing some of these heavy bowlders.

The gravel benches described above are roughly estimated by Mr. Blodgett to contain a total of about 500,000 cubic yards of material that can be hydraulicked. The gold tenor of the deposit as a whole has not been determined by systematic prospecting. Some mining done by hand methods six to eight years ago and some hydraulicking done on the central part of the upstream bench with a small plant have demonstrated the gold-bearing character of this deposit though no high values have been found. The operations so far conducted have been of a somewhat experimental nature. Under efficient hydraulicking, with proper appliances for saving all the gold, the recovery probably would have been improved.

The gold is rather fine, light, and flaky. A few small nuggets are said to have been found. It is estimated that one nugget had a value of about $3. The larger pieces show distinctly the effects of having been rolled out thin, as would be expected by the turbulent stream washing, of which there is abundant evidence. The commercial value of the gold is said to be $18 an ounce.

A small hydraulic plant was installed by the White River Mining Co. on the middle bench in 1908, and this has since been operated as the water supply permitted.

In the spring of 1913 a comprehensive plan for the hydraulic working of the bench ground along upper White River was commenced. This project included the bringing of water for ground-sluicing across the lower end of the glacial basin by means of a flume about 9,000 feet long. The flume is 40 inches wide and 20 inches high. Its intake from the river is tunneled 50 feet through a rocky point to assure a secure connection with the glacial stream, whose violent fluctuations in volume must be reckoned with. The flume line consists of about 7,000 feet of trestle work and about 2,000 feet of grading. Construction work was continued throughout the summer and the hope was entertained of completing it early enough in the fall to make a trial run to test the ground on the lower part of No. 3 bench. It is not known whether this was accomplished, but no doubt actual mining will be conducted during the summer of 1914.

If the operations prove the gold-bearing value of the bench deposits and the practicability of mining them with profit is then demonstrated, the deposits in the depression now occupied by Willow Creek should not be overlooked. This depression has every appearance of having been a former channel of White River when the knoll was the nose of a mountain spur from the eastern slopes of the valley which now rise steeply opposite bench No. 3. The present channel of White River appears to have been cut across this spur and thus formed the knoll. During a stage of this cutting the bedrock platform on which the No. 3 bench deposits now rest was eroded. Since then the river has cut its channel about 15 feet below the surface of the former valley floor at this place, leaving the narrow strip of bench along the border of the knoll on the right side of the river.

SOURCE OF THE PLACER GOLD.

It has been shown that the beach placers are formed by the concentration of gold disseminated in the sand and gravels of the coastal plain and that these, in turn, are probably glaciofluviatile deposits of White River. It is possible that other streams played a part in this formation of coastal-plain deposits, but if so they did not contribute any gold, for none of their gravels are known to be auriferous. There is no direct evidence of the bedrock source of the gold. No mineralization has been found in any of the Tertiary sediments that have been examined, and if any of these carry gold it is probably derived from other sources and deposited as alluvium. On the other hand, the main St. Elias Range is made up of metamorphic and igneous rocks, and the evidence from other parts of the chain indicates that these are locally mineralized. Therefore it is probable that the glacer gold was derived from quartz veins or other forms of bedrock mineralization occurring in the unsurveyed high ranges north of the Yakataga district.

It remains to consider how this gold reached its present position. The source of the beach gold having been traced to the stream placers, it is only necessary to consider these. The White River valley does not reach the metamorphic rocks believed to be the source of the gold but is separated from them by a broad belt of Tertiary terranes. The same is probably true of most of the streams draining the Yakataga district. It is evident, therefore, that the alluvial gold could not have reached its position in the river gravel by action of the present watercourses. If this placer gold has been transported by water, it must have been by an older drainage system, whch reached back into the metamorphic highlands. The Tertiary and Pleistocene sediments of the region are in part probably of fluviatile origin, and there is no inherent reason why some of them may not have carried placer gold. There is, however, no direct evidence that any of the conglomerates and sandstones are auriferous, and in fact the distribution of the present placers indicates that most of them do not contain alluvial gold.

One of these formations may, however, be an exception to this rule, and that is the fluviatile beds of conglomerate and the sandstones that overlie the bowlder-bearing sediments carrying Pleistocene fossils. It has been shown that this formation is abundant in the White River valley, and this is believed to be the immediate source of the placer gold. These rocks have not, however, been tested for gold, so that the proof of its auriferous character is by no means positive. Even if it carries gold, the chances of finding workable deposits are not great. If these ancient placers were rich, their dissection and the re-sorting of their gold contents would be expected to have yielded placers of a far higher gold tenor than those that have been developed in the White River valley.

An alternate hypothesis for the origin of the placers is not to be neglected. This assumes that the gold reached the White River valley by glacial transportation. The erosion of the rocks of the St. Elias Range by glaciers must carry with it the removal of any gold deposits that they contained. In this connection it becomes important to consider the source of the bowlders in the fluvial deposits of the White River valley. These consist chiefly of greenstone, granite, gneiss, and crystalline limestone. None of these rocks occur in the entirely unmetamorphosed sediments of the Robinson Mountains, except as detrital material. They are believed to occur in the St. Elias Range, 30 or more miles inland from the present coast line. These bowlders may have reached their present position by ice transportation. The White River glacier probably has its source in a névé field connected with the St. Elias Range. If this be so, the gold may have been transported by the same agency.

On the other hand, these igneous and metamorphosed rocks do occur abundantly as bowlders and cobbles in the Pleistocene terrane already referred to. The writer is of the opinion that the immediate source of these bowlders and also of the gold is in this Pleistocene terrane—a view which has already been presented. It should be said, however, for the glacial argument of the source of the gold, that some of the Pacific coast placers are known to have been formed by the reworking of ice-borne material. Such deposits at Yakutat Bay have been described by Tarr and Butler[1] and at Kodiak Island by Martin.[2] The distant transportation of gold by glacial ice is also suggested by the occurrence of beach placers apparently derived from glacial débris on Middleton Island.[3] This island is located in the Gulf of Alaska, about 50 miles from the mainland.

PETROLEUM.

All the best-known petroleum seepages of the Yakataga district are located near the base of the seaward slopes of the coastal ridge of Robinson Mountains. (See Pl. IV, p. 130.) These seepages are distributed along a line extending from a point near Yakataga Reef to Johnston Creek, a distance of about 18 miles. They are located from half a mile to 2 miles from the beach. There are about a dozen seepages distributed at irregular intervals along this line, but the extreme easternmost, on Johnston Creek about 1½ miles above its mouth, is the only one of considerable volume. Most of these seepages are

---

[1] Tarr, R. S., and Butler, B. S., The Yakutat Bay region, Alaska: U. S. Geol. Survey Prof. Paper 64, pp. 165-168, 1909.

[2] Martin, G. C., Mineral deposits of Kodiak and the neighboring islands: U. S. Geol. Survey Bull. 542, pp. 134-136, 1913.

[3] Brooks, A. H., The mining industry in 1912: U. S. Geol. Survey Bull. 542, p. 43, 1913.

little more than meager indications of oil in the form of sulphurous coatings or exudations along joint cracks of the rocks, also as iridescent films over moist rock surfaces and on any small pools of water that may be collected near by. Thick oily residue has accumulated in notable quantity only at the seepage on Johnston Creek. Here the discharge of rather fresh petroleum is free enough to furnish considerable quantities to the swift-flowing, turbulent stream so that appreciable quantities of oil are carried down its course to the ocean. A scum of oily residue also occurs on the cobble bars of Johnston Creek from its mouth up to the seepage. It is probable that a barrel or more of petroleum a day escapes from this seepage. The odor of petroleum was also noted at the mouths of Munday, Poule, Lawrence, and Crooked creeks, small streams that flow across the narrow coastal plain westward from Johnston Creek. (See Pl. IV.) The seepages on these streams are from 1 to 2 miles above their mouths and are not so indicative of the free escape of oil as the one on Johnston Creek.

Prospectors report the occurrence of petroleum seepages in the second ridge of the Robinson Mountains from the coast. Jack Dalton reports that he saw a strong petroleum seepage east of Icy Bay and not far from Yahtsee River. This locality may mark an eastern extension of the Yakataga oil field.

The westernmost of the main line of seepages lies near the base of the mountain slope where it joins the coastal plain, whereas those to the east lie in valleys separated by minor ridges from the seaboard. This line of seepages in part marks a series of east and west extending depressions occupied by the headwaters of streams flowing southward. The chain of depressions between the foothill belt and the main mountain front appears to lie along the axis of a symmetrical anticline, whose south limb is sharply flexed into a nearly vertical position and the dip of whose north limb is 15° to 45° N. All the seepages of petroleum reach the surface along the axial zone of this anticlinal flexure, which strikes about N. 70° W. The rocks, which are sandstones and shales, are provisionally assigned to the Oligocene.

The development of the depressions between the foothill belt of vertical strata and the main mountain front at right angles to the north and south trunk gorge valleys across that belt is primarily caused by the more rapid erosion and removal of material that has occurred along the zone of the anticlinal axis. Here the sharp flexuring of the strata has shattered the rocks, and thus exposed them to the more rapid disintegration and consequent removal by the streams.

The strata at the base of the exposed portion of the section in the vicinity of Johnston Creek seepage are chiefly made up of sandstones that are favorable for either storage or migration of petroleum. These sandstones are overlain by close-textured shales, which may have served as the retentive cover. The liberal escape of fresh oil at this locality might be used as an argument for considering this horizon—the lowest rocks exposed in the coastal mountain ridge—to be at or near the ultimate oil-bearing horizon. This can not, however, be demonstrated without drilling, and there are some strong arguments against this hypothesis which will not here be presented.

Several seepages occur at or near the base of the seaward slopes of the coastal mountain west of the lower White River valley nearly to Yakataga Reef. Here all the outcropping strata belong to the moderately northward-dipping limb of the anticlinal fold, the south limb being covered by the coastal-plain deposits or the ocean. The geologic structure of Yakataga Reef indicates distinctly the plunging nose of the anticline marked by the seepage.

The crest of this anticline appears to have a decided inclination to the west, but the dip is not so marked as that of its terminal nose at Yakataga Reef. This westward inclination amounts to a fall of at least 2,000 or 3,000 feet in the distance of about 18 miles along the seepage belt.

As the ultimate source of the petroleum at Johnston Creek seepage may be near if not at the outcrop from which the free flow of fresh oil comes (about 100 feet above sea level), it may be supposed that the oil-bearing bed becomes progressively deeper westward along the anticlinal axis. If this is so, it must be heavily covered by a greater thickness of strata in this direction. This may account for the more scanty escape of oil at the seepages in the western part of the belt. These views are based on the assumption that there is only one oil-bearing stratum developed along the anticline—the one marked by the free-flowing Johnston Creek seepage. All this is mere assumption, for there may be oil-bearing beds at several horizons in the section. There are in the exposed section several extensively developed porous sandstone and conglomerate members with impervious capping of fine-textured shale that should afford storage for petroleum. Some of these, where under deep cover toward the western part of the anticline, may contain oil. Only intelligently directed drilling will determine these matters.

The evidence in hand indicates that the search for oil should not be nearly so involved with structural complexities as in the Katalla oil field, in the Controller Bay district. In the Katalla field folding and faulting are so intricate that the drilling thus far done has not proved very satisfactory. The essential structural factors presented in the Yakataga seepage belt do not seem to be any more complex than those met in some of the productive fields of California. If anything, the structure governing the occurrence of petroleum in the Yakataga district is probably more simple than that of some of the well-known California fields. If this is true, possibly only a small amount of intelligent drilling will be necessary to prove the commercial value of the Yakataga belt. The inaccessibility of the field and the local difficulties of transportation will be strong deterrents to development. The discussion of transportation is reserved for a later section of this report.

There are no complete tests of the petroleum from the Yakataga district, and, in the absence of any drilling, such as have been made are necessarily of samples taken from seepages in which there has been a loss of the volatile compounds. There is every reason to believe that the Yakataga petroleum is of the same high grade as that of the Katalla field. The Katalla petroleum is a refining oil of the same general nature as the Pennsylvania petroleum. Like that oil, it has a high percentage of volatile compounds, a paraffin base, and almost no sulphur. The following table, taken from Martin's report,[1] summarizes the available information about the composition of the oil from the two fields:

Summary of analyses and tests of Katalla and Yakataga petroleum.

Locality.	Color.	Specific gravity.	Gravity.	Flashing point.	Benzine.	Kerosene.	Lubricating oil.	Residue: Coke and loss.
KATALLA FIELD.			°*Beaumé.*	°*F.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Katalla, well, 10[a]	....	0.8280	39.1	....	21.0	51.0	28.0	....
Do.[b]	....	.7958	45.9	....	38.5	31.0	21.5	9.0
Do.[c]	Light green.	.7957	45.9	70-80	38.5	31.0	21.5	9.0
Do.[c]	....	.800	....	....	34.2	34.4	16.5	14.5
Do.[d]	Dark red....	.802	....	—60	....	....	....	....
Do.[d]	.....do.....	.790	....	—60	....	....	....	....
(?)[d]	....	.869	....	....	....	19.0	78.6	1.7
(?)[d]	....	.914	....	....	....	9.0	87.6	2.7
(?)[d]	....	.800	....	....	24.8	53.9	16.7	1.2
Katalla Meadow[d]	Dark brown.	.929	....	240	....	....	....	....
Do.[d]	....	.901	....	156	....	....	....	....
Do.[d]	....	.874	....	156	....	....	....	....
Do.[d]	....	.869	....	152	....	....	....	....
Do.[d]	....	.961	....	266	....	....	....	....
Burls Creek[d]	Dark red-brown.	.942	....	234	....	....	....	....
YAKATAGA FIELD.								
Johnston Creek[d, e]	Dark brown.	.964	....	200	....	....	....	....
Do.[d, e]	.....do.....	.879	....	178	....	....	....	....
Poule Creek[d, e]	.....do.....	.970	....	250	....	....	....	....
Do.[d, e]	.....do.....	.881	....	67	....	....	....	....
Do.[d, e]	.....do.....	.914	....	156	....	....	....	....
Crooked Creek[d, e]	.....do.....	.921	....	172	....	....	....	....
Oil Creek[d, e]	.....do.....	.855	....	108	....	....	....	....
Yakogelty[d, e]	.....do.....	.937	....	246	....	....	....	....
Morrison Creek[d, e]	.....do.....	.991	....	270	....	....	....	....
Argyll Creek, Icy Bay[d, e]	.....do.....	.962	....	310	....	....	....	....

[a] Sample collected by G. C. Martin, test by Penniman and Browne. U. S. Geol. Survey Bull. 335, p. 121, 1908.

[b] Oliphant, F. H., The production of petroleum in 1902: U. S. Geol. Survey Mineral Resources, 1902, p. 583, 1903.

[c] Stoess, P. C., The Kayak coal and oil fields of Alaska: Min. and Sci. Press, vol. 87, p. 65, 1903.

[d] Redwood, Boverton, Petroleum, vol. 1, 2d ed., p. 198, 1906.

[e] The exact localities of seepages where these samples were taken are not known, but they are believed to be in the Yakataga field.

In 1897, soon after the occurrence of petroleum in Yakataga became known, a continuous tract of land about 1½ miles wide and 20 miles long was located and surveyed along the belt of seepages.

---

[1] Martin, G. C., Geology and mineral resources of the Controller Bay region, Alaska: U. S. Geol. Survey Bull. 335, p. 128, 1908.

This tract included all the known seepages in the coastal ridge of Robinson Mountains and covered the anticlinal axis from Johnston Creek on the east to its westward-plunging nose at Yakataga Reef. The original locations aggregated some 50 square miles or about 32,000 acres. Since then, however, the locators have relinquished much of this land in order to concentrate their assessment work on claims covering chiefly the actual seepages.

COAL.

Relatively few geologic observations were made in what is believed to be the coal-bearing area of the district. The coal field lies chiefly in the higher part of the Robinson Mountains and the surveys reached only its southern margin except along the valley of Duktoth River. Here the mountains were penetrated for a distance of more than 25 miles, and thus a part of the coal field was traversed, but unfortunately not many outcrops were seen, and detailed information regarding the structure of the field and thickness of beds are lacking. So far as known no coal claims have been staked or coal beds prospected in this field.

Though only a few exposures of coal were actually seen in place, the river gravels and glacial débris afforded evidence of a considerable coal field to the north. The gravels of Duktoth River and of the streams draining the Bering Glacier to the west include much coal. What is believed to be the approximate southern boundary of the coal field is indicated on the map; its northern boundary is unknown. Information furnished by prospectors indicates that there is an approximately east and west trending coal belt at least 10 miles wide. This is cut off on the west from the Bering River coal field by the Bering Glacier. Its easterly extension is not known. Coal has, however, been found on the southwestern flank of Mount St. Elias. Broke [1] mentions the occurrence in this area of coal beds 6 and 8 feet thick. Some of this coal he burned in the camp fire. All this evidence goes to show the probability of a considerable development of coal measures in the northern part of the Yakataga district.

As already mentioned on page 130, the rocks of the coal measures are chiefly arkoses, sandstones, and shales and are believed to be of the same age (Eocene) as the coal measures of the Bering River field. It is also believed that the southern boundary is marked by a thrust fault which has brought the coal-bearing rocks on top of the younger Pliocene sediments. The structure of the field is unknown, but in the absence of information to the contrary it is fair to assume that the coal measures are folded and faulted similar to those of the Bering River field.

---

[1] Broke, George, With sack and stock in Alaska, pp. 86-91, London, 1890.

As only two outcrops of coal were actually examined there are few data concerning the thickness of beds. One of these outcrops occurs in a bluff on Duktoth River about 22 miles from the mouth. The thickness measures 5 feet 6 inches, and the floor and roof are composed of shale. The middle of the bed shows a shale parting about 16 inches thick. Its strike is about N. 80° E., and the dip is 30° N. The second outcrop is located on the slope of Duktoth Valley, 200 feet above the floor and about 25 miles from the mouth of the river. This bed strikes about N. 80° E. and dips 35° N. It includes 4 feet of clean coal and has a shale roof and floor. A sample taken from the outcrop of this bed was analyzed by A. C. Fieldner, of the Bureau of Mines, with the following results:

Analysis of coal from Duktoth Valley, Yakataga district.

	Air dried.	Moisture free.
Moisture	1.05	....
Volatile matter	11.45	11.57
Fixed carbon	64.05	64.74
Ash	22.45	23.69
	100.00	100.00
Sulphur	.66	....

The large percentage of ash in this coal may in part be due to impurities caused by surface weathering, but otherwise this particular coal, though of a bituminous grade, has no commercial value.

Whether there are better coals in the district can only be determined by further prospecting. The chances are that a careful search would be rewarded by the discovery of better coals. On the other hand, the Yakataga coals are so much more inaccessible than those of the Bering River field that even if found to be of the same grade they could not now be exploited for exportation in competition with those of the Bering River field. In view of the abundance of timber and of the petroleum in the Yakataga district it is not likely that any coals found in these high ranges would be utilized, even as a local source of fuel. Therefore the coal of the Yakataga district can not be considered an available asset until the more accessible fuel approaches exhaustion.

HARBORS AND TRANSPORTATION.

The Pacific coast between Controller and Yakutat bays, a distance of about 175 miles, is open to the full sweep of the ocean, with no shelter for even a light-draft launch. The only possible exception is the recently opened indentation at the western margin of Malaspina Glacier, known as Icy Bay. (See description, pp. 150–151.) There are no permanent Indian settlements along this stretch of coast.

In their journeys by boat between settlements at Yakutat and Controller bays the natives occasionally made landings at Yakataga. This is indicated by the name Yakataga, of Tlingit derivation, which means "canoe landing place." The natives evidently so named this rocky reef because they considered it the most favorable place along this part of the coast to land their large dugout canoes.

The white population of the Yakataga district has fluctuated greatly since the first settlement was made, in 1898. Now there are about a score of permanent residents, whereas in 1903 to 1905 there were probably 200 or 300. As Yakataga Reef is the only place along this part of the coast where supplies may be landed with any facility, it has always been, by force of natural conditions, the principal point of settlement. This settlement comprises a straggling collection of log cabins and storehouses which may have numbered 30 or 40 at the time of greatest population. Only about half a dozen of these are in use. Many are dilapidated, and others have been burned for firewood.

During the summer of 1903, when beach mining was at its height, coastwise steamers called at Yakataga Reef, weather permitting, about once a month. This service was discontinued as soon as the early excitement caused by the mining of the richest beach placers had subsided. Since 1903 coastwise steamers have seldom called at Yakataga Reef, for it is not a good roadstead and the condition of the surf is rarely favorable for landing. Moreover, the trade inducements now amount to little.

The great glacier barriers that bound the district on the east, north, and west make it almost inaccessible by land. There is only one overland route of approach and this presents serious difficulties. It follows the shore for about 50 miles from Cape Suckling, at the eastern side of Controller Bay and about 30 miles from Katalla. For 30 miles east of Cape Suckling this route passes along the near-by front of Bering Glacier, and half a dozen swift glacial rivers issuing from beneath the ice must be crossed. All of these streams are more or less dangerous to ford because of quicksands in their constantly shifting channels. Several are so large that they may be crossed by rafts or boats. The others may be forded at times of low water, but this is always a hazardous undertaking even under the most favorable conditions. There are also two swift glacial rivers between the eastern margin of Bering Glacier and Yakataga Reef that must be crossed by boats or rafts. As there are no habitations along this route, it is necessary to carry all supplies for the journey on one's back, and it is also best to transport a canoe. This route is seldom traveled and then only under guidance of those familiar with its dangers. Several men have lost their lives in attempting this trip.

All landings on this part of the coast must be effected through the surf in small open boats. The only favorable place for accomplishing this with even approximate safety is at Yakataga Reef, a low rocky point that juts into the ocean about half a mile. This affords a slight protection from the breaking swell when it is not stormy. Even here it is only possible to make a safe landing at times of very moderate or calm weather. Southeast winds throw breakers against the east side of the reef, southwest winds against its west side, and only at low tide are the rocks not more or less awash if there be any ocean surge.

The supplies needed by the present small population of miners are for the most part brought in launches from Katalla, 85 miles to the west by steamer route and the nearest regular port of call. These launches are navigated by men who closely observe the weather changes and by experience are generally able to foretell the conditions for landing at Yakataga Reef a day or so in advance. At such opportune times quick trips are made with launches along the coast, generally at night so as to arrive at Yakataga Reef in the morning and begin to land the freight through the surf by daylight. This is usually accomplished within a few hours or a day at the most and the return made to the shelter of Controller Bay without delay. By this means the district is served with supplies and mail in an irregular manner at such times as the weather permits and its needs demand. It is not unusual for a month to pass during which no favorable opportunity for landing at Yakataga Reef occurs.

Until recently what is now Icy Bay was occupied by Guyot Glacier. Since 1904, however, there has been a marked change going on along the southwestern margin of the terminal lobe of this glacier. The ice has retreated and a considerable embayment formed. This is known as Icy Bay, which might be used as a harbor for Yakataga district if it were free from drifting icebergs, and if its western shore should prove to be deep enough for anchoring lighters near the land or to afford favorable conditions for the construction of a pier.

The writer's survey of Icy Bay, the results of which are indicated on the accompanying map, was very hasty and accomplished without the use of a boat. Hence no soundings were made and the character of the sea bottom could not be determined.

To determine the possible commercial value of this embayment it will be desirable to review briefly the history of the glacial movements in the vicinity as recorded by several observers during the past 120 years. This matter will be considered in greater detail in the final report. Vancouver[1] was the first to map this part of the coast, which he did in 1794. At this time the bay had approxi-

---

[1] Vancouver, George, A voyage of discovery to the northern Pacific and around the world, 1790-1795, new edition, vol. 5, pp. 348-409. London, 1801.

mately its present outline. Later the Guyot Glacier, now occupying the head of the bay, moved forward and not only filled the entire indentation but jutted out to sea beyond its confines and thus Icy Bay became Icy Cape and as such has long been known. There have been several fluctuations in the ice front during the past century, but these need not be considered here. It will suffice to state that during the past 10 years the front of Guyot Glacier has retreated about 10 miles, leaving the bay much as Vancouver saw it. The ice cliff of Guyot Glacier, from 200 to 250 feet high and about 5 miles long, now bounds the entire head of Icy Bay and discharges its bergs into it.

The bay, though it presents a 7-mile opening to the south, affords considerable shelter (Pl. IV, p. 130). The ocean surf is broken by a bar which lies off Icy Cape at the southwestern entrance of the bay. Conditions adverse to commercial utilization are (1) the drift ice from Guyot Glacier and (2) the known shoals of the west side of the bay.

The large amount of drift ice in the bay, at least during the summer, would present a great hindrance to boats landing cargoes on its west shore where they would be available to the Yakataga district. Though this is not known to be the condition on the east side of the bay, nothing would be gained by landing supplies there because that area is completely surrounded by impassable barriers of glacial ice.

The west side of Icy Bay, though not sounded, appears to be rather shallow for a distance of at least half a mile from shore. This is shown by the stranding of comparatively small icebergs. In addition to this, smaller masses of ice are generally so closely packed along this shore for a width of a quarter of a mile that even small boats would find it difficult to effect a landing, especially as the ice grinds together when moved by the ocean swell which enters the bay.

There is a question whether piers could be built out from the west shore to deep water that would withstand the damage of this drifting ice. Even if such piers should resist the impacts and pressure of the ice they would certainly furnish obstruction to the free movements of the ice as it now drifts along the shore. As a result, large quantities of ice would accumulate and clog about such artificial obstacles and thus not only make it difficult for vessels to reach the piers but might also damage their hulls. A possible solution to such a problem would be to build two piers, so that all large masses of ice would be excluded from a certain area, thus creating a small inclosed basin in which to moor vessels.

Because of the conditions described Icy Bay is not now available as a landing place for the Yakataga district. It seems doubtful whether the commercial interests to be served will justify the expenditure for improvements necessary to make the harbor available.

A further recession of Guyot Glacier, which is likely to take place, would bring about favorable changes. The glacier might then no longer discharge its bergs into the bay, which would eliminate the drift ice. On the other hand, the advance of the glacier is not precluded, in which event the bay might again be entirely closed to navigation, and any harbor improvements destroyed.

If Icy Bay is ever utilized to serve the Yakataga district it will be necessary to build a wagon road. tramway, or light railroad from its western shore to the placer and petroleum deposits. Probably a tramway, for the construction of which there is an abundance of timber, would be cheaper than a wagon road. Aside from the bridging of several considerable glacial streams, whose channels are ever shifting, such an undertaking would not be difficult.

The transportation of supplies along the coast between Yakataga and Umbrella reefs presents some difficulties. A few horses have been brought to the district and used in a wagon with broad-tired wheels to haul supplies from Yakataga Reef to White River (8 miles) and thence by a wagon road that has been built up that stream for about 2 miles. Beyond the end of the wagon road there is a very rough foot trail to the White River glaciers, totally impassable for horses and even difficult and dangerous for the foot traveler who is burdened with a pack. At low water pack horses can be taken up the White River bars to the glacier. Most of the supplies have been taken up White River in a small dugout canoe, which, when loaded with about 600 pounds, can be dragged up the swift current by two men.

When hard freezing weather begins the discharge of White River and of other glacial streams becomes low and then for a few weeks glare ice forms along most of the river bed. At such times heavy loads may be drawn up the stream on sleds, but heavy falls of soft snow soon cover the ice deeply and make sledding more difficult. Nevertheless, in the absence of well-constructed roads this is probably the most effective method of transporting supplies into this part of the district.

As the beach miners can not afford to keep horses, they transport their supplies along the shore from Yakataga Reef to the places of operation by means of small two-wheeled carts. These they either draw themselves or with the aid of dogs in the same manner as winter sledding is done throughout much of Alaska. A team of dogs will haul 200 to 300 pounds on one of these carts. Times of low tide are chosen for this manner of travel, because the ocean strand then presents a more compact and even road below high-tide level. Even here, however, the wheels of the carts sink into the coarse sandy stretches in spite of their broad tires, and the work of conveying a load of several hundred pounds a few miles along the beach is no easy task. Only small portions of the beach are compact enough to afford firm footing, and considerable stretches of it are too thickly strewn with cobbles and bowlders to render the use of carts satisfactory. This is especially the condition east of Umbrella Reef to Icy Bay, a distance of about 25 miles. Two large glacial streams and several lesser ones debouch across this section of the coastal plain, and thus present obstacles to transportation.

West of Yakataga Reef the many swift glacial streams already mentioned present similar difficulties. Though beach carts may be used along the shore between the rivers, it is necessary to carry them across each stream at some risk, because they are awkward to handle, especially so in the canoes or small boats that are necessary to cross the larger rivers.

Some of the larger rivers may be ascended with light boats, but only at considerable risk. To reach other parts of the inland region it is necessary to carry all supplies on the backs of men, and even this mode of travel is greatly hindered by the heavy timber, much of which is windfallen. Further obstacles are found in the dense underbrush, covering much the larger part of the coastal plain and the valleys up to the glaciers, as well as the steepest mountain slopes up to an altitude of 3,000 feet. In addition to these difficulties the prevailingly rainy or misty atmospheric condition keeps the dense growth of vegetation dripping with moisture that soon thoroughly wets one who travels through it. But the most serious obstacles to satisfactory progress in almost any inland direction are the large glacial streams, which must be forded. The channels of these streams are continually changing in depth and shifting in position. All are so heavily laden with silt that little may be judged of the nature of their beds without actually wading into them. Often a place of safe crossing must be sought for several miles along their courses.

The high mountainous part of the Yakataga district has been traversed only in an exploratory way by parties especially equipped for glacial travel. The feasibility of this has been demonstrated by the indomitable pioneering of the Alaska prospectors, small parties of them having made several trips from Yakataga, across the great interior glaciers, to the upper valley of Chitina River and return. The shortest route by which this journey may be made is said to be over about 50 miles of glacial ice.

PRELIMINARY REPORT ON A WATER-POWER RECONNAISSANCE IN SOUTH-CENTRAL ALASKA.

By C. E. Ellsworth and R. W. Davenport.

INTRODUCTION.

FIELD WORK AND ASSISTANCE.

A reconnaissance of the water supply of south-central Alaska with particular reference to water power was made by the writers in 1913. Field work began May 5 and was continued until November 25. The area covered extended from the Controller Bay region on the east to Kenai Peninsula on the west. The Copper River basin was studied in some detail as far north as Copper Center. Most of the important mining sections near Prince William Sound were visited and a hasty trip was made to the Willow Creek district.

This report is a brief preliminary statement of the data obtained and conclusions reached during the above reconnaissance. A more complete report giving the results in detail is now in preparation for publication as a water-supply paper.

It was beyond the scope of this investigation to visit all the streams in the different districts or to obtain sufficient data regarding their physical characteristics to make any accurate estimates of the amount of power that could be developed from them. It is hoped, however, that the results of this reconnaissance may form a basis for a more intelligent conception of the magnitude and distribution of the water powers in this portion of Alaska, for it is believed that they are now generally overestimated in the popular mind.

Special acknowledgments for gage readings and other services are due to the Copper River & Northwestern Railway Co., the Ellamar Mining Co., the Kennicott Mines Co., and Messrs. G. L. Banta, W. A. Dickey, S. M. Graff, Charles G. Hubbard, A. R. Ohman, C. I. Olsen, Herman Schmesar, and L. W. Storm.

METHODS OF INVESTIGATION.

The two features of a stream basin that control its water-power capacity are (1) the run-off and its variation throughout the year and (2) the head under which the water can be utilized at the wheels. A third feature, however, that will determine the practicability of the project on many Alaskan streams is the storage capacity that can be created above the point of diversion.

To determine the run-off from the basins studied measurements of discharge were made by a current meter, and where practicable gages were installed from which the elevation of the water surface was read at various intervals of time depending on the proximity of the observer. After making measurements of discharge at different gage heights the discharge at any gage height can be estimated by plotting the measurements on cross-section paper with discharges as abscissas and gage heights as ordinates and then drawing a curve through the plotted points. A rating table is then prepared showing the discharge for various gage heights. The reliability of this table depends on the accuracy of the discharge measurements and gage readings and also on the permanency of the stream channel. Where gage readings are not available the discharge is, of course, unknown except at the time of the engineer's visit, when discharge measurements were made. Such measurements are called miscellaneous and should be used with care in estimating the flow at other times, because of the rapid fluctuation that is characteristic of the streams. The records do not include the low-water season, which lasts from late in the fall until about the first of May.

The head in feet that can be obtained at the sites examined was determined either by aneroid barometer or from the following topographic maps:

Controller Bay region, scale 1: 62,500, contour interval 50 feet. (Price 35 cents.)
Chitina (reconnaissance), scale 1: 250,000, contour interval 200 feet. (Published in Bulletin 374.)
Nizina district, scale 1: 62,500, contour interval 50 feet. (Published in Bulletin 448.)
Valdez Bay and vicinity, scale 1: 62,500, contour interval 50 feet.
Ellamar and vicinity, scale 1: 62,500, contour interval 100 feet.
Kenai Peninsula (reconnaissance), scale 1: 250,000, contour interval 200 feet.
Willow Creek district, scale 1: 62,500, contour interval 100 feet.

It was entirely beyond the scope of this reconnaissance to determine the capacity of the reservoir sites. Lakes that might furnish natural storage were measured on existing maps, so far as they occur in surveyed areas. The areas of some lakes situated in unsurveyed districts were estimated merely by inspection and, of course, statements based on such estimates can be considered only roughly approximate.

No attempt was made to estimate the capacity of reservoirs that would be created by the construction of dams.

In the course of the reconnaissance the topography and rock formation at the outlet of lakes and other basins where it might be desirable to create storage reservoirs were hastily examined with reference to the possibility of constructing dams. Distances were measured by pacing where the sites were easily accessible; elsewhere they were estimated. Elevations were determined by hand level, by aneroid barometer, or by estimation.

Statements in this report relating to other physical features of the basins, such as forests, glaciers, general topography, and soil covering, are based either on actual observation by the writers or on information obtained from existing reports and maps prepared by other members of the Survey.

DEFINITION OF TERMS.

The volume of water flowing in a stream—the run-off or discharge—is expressed in various terms, each of which has become associated with a certain class of work. These terms may be divided into two groups—(1) those which represent a rate of flow, as second-feet, gallons per minute, miner's inches, and discharge in second-feet per square mile, and (2) those which represent the actual quantity of water, as run-off (depth in inches) and acre-feet. The units used in this report are second-feet, second-feet per square mile, run-off (depth in inches), and acre-feet. They may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second and is the unit for the rate of discharge of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second. It is generally used as a fundamental unit from which others are computed by the use of the factors given in the following table of equivalents.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

"Run-off (depth in inches)" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

An "acre-foot" is equivalent to 43,560 cubic feet and is the quantity required to cover an acre to the depth of 1 foot. The term is commonly used in connection with storage for irrigation work.

In the tables the column headed "Accuracy" shows the degree of reliability which the record of the mean monthly flow is believed to possess. "A" indicates that the mean monthly flow is probably accurate within 5 per cent, "B" within 10 per cent, "C" within 15 per cent, and "D" within 25 per cent. Special conditions are covered by the footnotes.

CONVENIENT EQUIVALENTS.

The following is a list of convenient equivalents for use in hydraulic computation:

1 second-foot equals 40 California miner's inches (law of March 23, 1901).
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second.
1 acre equals 43,560 square feet.
1 acre equals 209 feet square, nearly.
1 cubic foot of water weighs 62.5 pounds.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
1⅓ horsepower equals about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Second-feet} \times \text{fall in feet}}{11}$ = net horsepower on water wheel realizing 80 per cent of theoretical power.

CLIMATE.

The climate within the area discussed in this report varies widely. Meteorologic data have been collected at many points in south-central Alaska, and some general conclusions can be drawn with considerable certainty. Most of the Weather Bureau stations, however, are situated near sea level, and the records are for that reason of considerably less value in estimating stream flow than they would be if the stations were situated where average conditions could be observed. The precipitation at the higher altitudes is believed to be much greater than at sea level, but no definite comparison can be made until observations have been made at the different elevations.

As most of the streams head in glaciers or perennial snows, temperature plays fully as important a part as precipitation in their discharge.

In the table below are summarized precipitation and temperature records at several localities in south-central Alaska. All the stations are near the coast except Copper Center, which is 70 miles inland from the head of Prince William Sound. The records show that the heaviest precipitation along the coast occurs during September, October, November, and December; farther inland the months of maximum precipitation are July, August, and September. The mean monthly temperature is below freezing for seven months in the year at Copper Center, and for four to six months on the coast. The average number of rainy days in a year is 63 at Copper Center, about 150 at Seward and Sunrise, from 150 to 200 at Valdez, and about 200 at Cordova and Katalla.

Records of snowfall are rather meager but indicate about 10 feet annually at Cordova, 12 feet at Valdez, 6 feet at Seward, and 3 feet at Copper Center. In the mountains the snowfall is much greater and accumulates in enormous drifts, which in sheltered spots last throughout the summer.

Summary of precipitation (inches) and temperature (° F.) at Weather Bureau stations in south-central Alaska.

Copper Center.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	0.57	0.46	0.17	0.07	0.39	0.86	1.56	1.12	1.13	0.96	0.76	0.74	8.79
Maximum temperature	49	49	49	64	80	96	87	87	80	66	49	50	....
Minimum temperature	−74	−55	−48	−26	18	22	22	20	3	−26	−46	−53	....
Mean temperature	−10.8	2.3	14.3	29.0	44.1	53.1	55.4	52.4	42.9	27.7	4.6	3.3	27.1

Cordova.

Mean precipitation	9.86	9.23	8.82	9.80	9.84	6.67	6.30	11.69	19.91	20.21	11.47	13.97	137.77
Maximum temperature	47	58	61	70	72	80	86	80	84	72	60	49	....
Minimum temperature	2	4	1	15	28	34	33	40	31	26	11	5	....
Mean temperature	27.8	30.3	31.6	37.0	44.8	50.9	56.2	55.4	48.7	43.9	33.2	29.7	38.9

Fort Liscum.

Mean precipitation	7.01	5.08	6.00	3.58	4.12	2.45	5.03	7.83	9.29	9.06	6.01	8.36	73.82
Maximum temperature	45	45	54	53	71	79	82	80	84	57	47	45	....
Minimum temperature	−14	−12	−8	2	25	30	32	30	17	10	0	−13	....
Mean temperature	20.7	21.8	26.1	27.8	41.8	49.8	52.0	50.1	44.9	35.8	29.1	23.9	35.2

Katalla.

Mean precipitation	11.88	3.94	4.54	7.75	6.30	6.26	11.30	9.67	15.36	25.62	12.44	11.48	126.54
Maximum temperature	42	36	35	50	67	80	78	84	76	54	52	44	....
Minimum temperature	4	2	4	23	30	41	42	44	37	22	20	4	....
Mean temperature	19.0	23.5	23.1	35.8	44.2	50.0	55.0	59.4	52.0	41.7	34.4	32.0	39.2

Kenai.

Mean precipitation	0.66	0.70	0.75	0.47	0.85	0.92	2.31	3.61	3.06	2.03	1.07	0.87	17.29

Seward.

Mean precipitation	2.01	4.92	3.34	3.70	3.53	1.83	2.66	5.33	7.18	8.62	7.54	8.13	58.79
Maximum temperature	43	44	49	65	75	84	83	85	84	64	49	45	....
Minimum temperature	−11	−12	−7	10	26	32	40	33	27	11	9	−10	....
Mean temperature	19.0	27.0	31.3	36.5	43.5	45.8	54.1	54.4	48.7	39.0	31.1	25.8	39.5

Summary of precipitation (inches) and temperature (°F.) at Weather Bureau stations in south-central Alaska—Continued.

Sunrise.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	2.44	2.70	1.78	2.74	1.95	1.04	2.00	2.98	3.34	4.67	4.30	4.21	34.15
Maximum temperature	44	57	58	60	76	79	76	78	72	59	51	48	....
Minimum temperature	−29	−27	−23	−4	23	27	34	28	17	2	−15	−26	....
Mean temperature	10.4	19.4	24.9	33.0	43.1	49.8	53.6	51.6	44.3	34.1	22.6	17.7	33.5

Valdez.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean precipitation	4.16	6.03	5.49	2.21	3.60	1.75	3.72	4.32	9.08	5.59	2.69	8.99	57.63
Maximum temperature	38	49	58	59	74	91	82	76	79	61	47	49	....
Minimum temperature	−27	−25	−9	−1	22	33	38	31	22	5	−3	−21	....
Mean temperature	11.5	18.6	25.3	35.2	45.2	53.4	57.0	58.3	48.9	36.2	25.2	18.5	36.1

CONTROLLER BAY REGION.

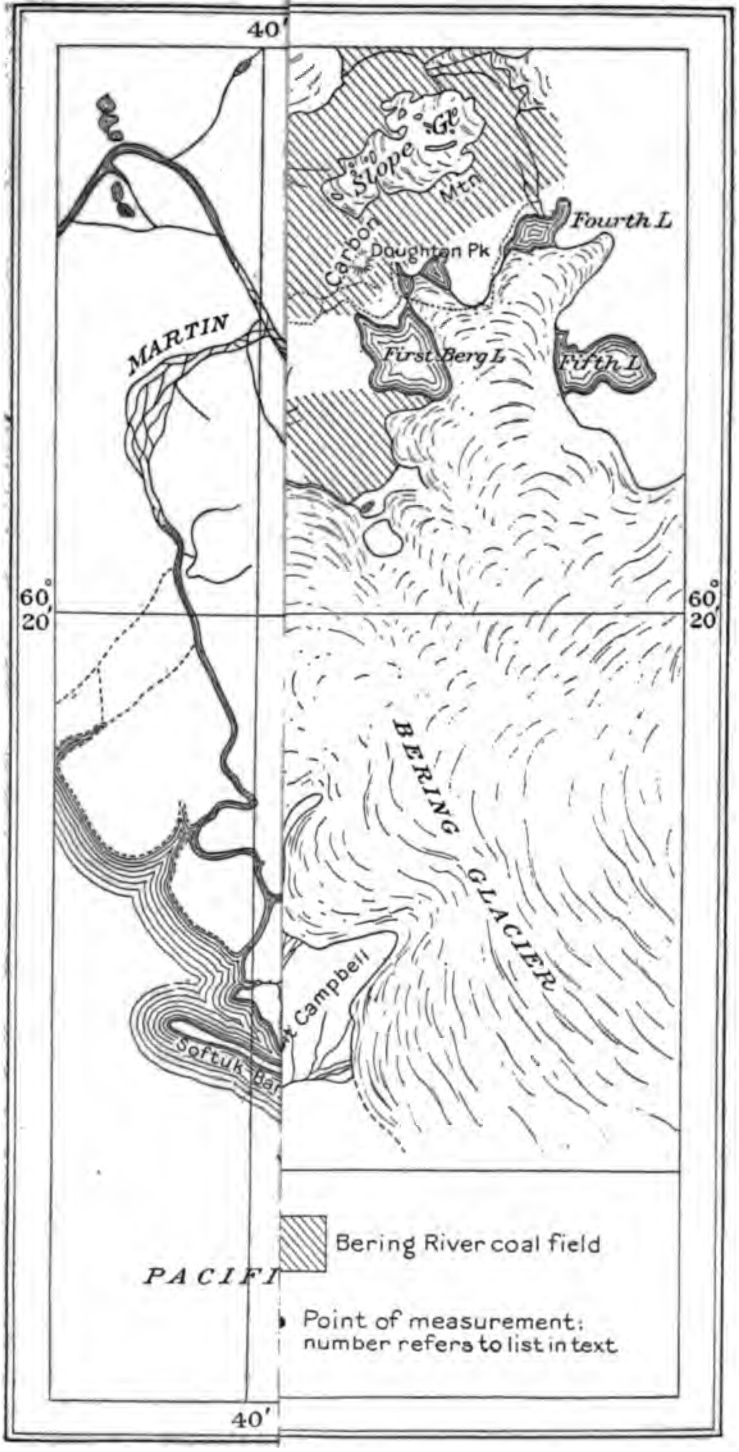
GENERAL FEATURES.

The Controller Bay region (see Pl. V) occupies an area of about 500 square miles, bounded by the Chugach Mountains on the north, Bering Glacier on the east, the Pacific Ocean on the south, and the Copper River delta on the west. The region is exceedingly varied in topography. It is made up of southern spurs from the Chugach Mountains and isolated peaks to the south ranging from 1,000 to 3,000 feet high, with many low swampy areas and numerous lakes.

Katalla, the post office and commercial center for the entire region, is situated on the north shore of Katalla Bay about 10 miles east of Controller Bay. Supplies are landed by small launches from ocean-going vessels, which anchor about half a mile from the shore. Katalla is one of the proposed outlets for the Bering River coal fields, which lie from 20 to 30 miles northeast of the town. There are also two producing oil wells tributary to Katalla.

But few data are available regarding the climate of this region. (See p. 158.) The yearly precipitation probably averages over 100 inches, with a rather heavy snowfall. The summers are cool and cloudy and the winters are moderate.

Spruce and hemlock are the principal trees. They occur in heavy stands and reach diameters of 2 to 3 feet. The best timber lies along the foothills below an elevation of 1,000 feet. The United States Forest Service makes an approximate estimate of 2,130,000,000 feet board measure for the stands on Ragged Mountain and in the vicinity of Martin River and Bering Lake.


40'
Slope Gl
Mtn
Carbon
Doughton Pk
Fourth L
MARTIN
First Berg L
Fifth L
60° 20'
60° 20'
BERING GLACIER
Campbell
Softuk Bar
PACIFI
▨ Bering River coal field
● Point of measurement: number refers to list in text
40'

STREAM FLOW.

MEASURING POINTS.

The following list gives the locations at which discharge measurements were made in 1913 in the Controller Bay region. The numbers refer to Plate V:

1. Bering River above Stillwater Creek.
2. Canyon Creek at mouth.
3. Stillwater Creek 1 mile above mouth.
4. Trout Creek one-fourth mile above mouth.
5. Clear Creek at Cunningham's camp.
6. Clear Creek near Katalla.

MISCELLANEOUS MEASUREMENTS.

No daily records of stream flow have been kept in the Controller Bay region. Several miscellaneous measurements that were made in 1913 are listed in the following table:

Miscellaneous measurements in Controller Bay region in 1913.

Date.	Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square-mile.
				Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
July 11	Bering River	Controller Bay	Above Stillwater Creek.	3,950		
11	Canyon Creek	Bering River	Mouth	179		
11	Stillwater Creek	do	1 mile above mouth	858		
11	Trout Creek	Stillwater Creek	¼ mile above mouth	126	2.3	5.48
11	Clear Creek	do	Cunningham's camp	37	6.3	5.87
13	do	Katalla River	1 mile above mouth	151	6.8	22.1

WATER POWER.

Bering River is the principal stream in the Controller Bay region. It and its tributaries drain the western part of the area in which the coal fields are located. The run-off is derived largely from the Bering River and Martin River glaciers.

The principal water-power sites in this region are on Bering River at the outlet of First Berg Lake and Stillwater Creek at Kushtaka Lake outlet. At the former site a head of about 650 feet could be obtained by carrying water from First Berg Lake through Carbon Mountain in a tunnel about a mile in length. From a measurement made on July 11, 1913, it is estimated that the discharge at the outlet of the lake on that date was about 3,000 second-feet. A flow of 3,000 second-feet with an efficiency of 70 per cent at the wheel would develop 155,000 horsepower. The measurement mentioned was made in the season of maximum run-off, and as no winter records are available it is difficult to estimate the amount of power that could be developed during that season; but inasmuch as with the head available (650 feet) over 5,000 horsepower could be produced for every 100 second-feet of discharge, it seems reasonable to predict that by drawing on storage from the lake, 5,000 to 10,000 horsepower could be produced throughout the year.

Kushtaka Lake has an area of 4.7 square miles. Its level could be raised from 20 to 30 feet by a dam at the outlet, thus obtaining a storage capacity of 60,000 to 90,000 acre-feet. A fall of at least 35 feet below the normal lake level could be obtained by carrying the water in a pressure pipe for a distance of about 1 mile. Under that head, with an efficiency of 70 per cent, about 275 horsepower could be realized at the wheel for every 100 second-feet of discharge. The only information regarding the flow consists of the one discharge measurement listed in the table. Considering the storage that could be created it is estimated that from 500 to 1,000 horsepower could be developed at minimum flow in the winter and from 1,000 to 2,000 horsepower from May until October.

A few hundred horsepower could probably be developed on some of the smaller streams for five or six months in the year, but it is doubtful if sufficient storage could be created to make possible the development of more than very small power in the winter.

The only market that can be foreseen for these powers is the energy that will eventually be required in connection with the mining of the coal beds. Coal of good quality will then be available at a comparatively low cost, and the poorer coal that would not be suitable for the open market will offer a fuel for local power development so cheap that water power will have to be produced in the most economical manner if it is to become a successful competitor.

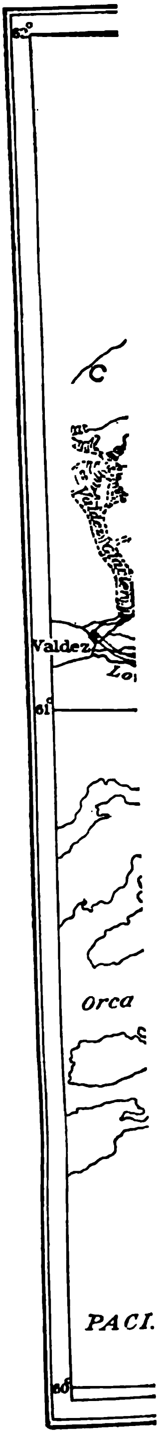
COPPER RIVER DRAINAGE BASIN.

GENERAL FEATURES.

The Copper River drainage basin, which contains valuable gold and copper deposits, occupies an area of about 23,000 square miles in the southeast corner of the main body of Alaska. (See Pl. VI.) It may be divided into four physiographic provinces—the Chugach Mountains on the south, the Wrangell Mountains on the east, the Alaska Range to the north, and the Copper River Plateau on the west.

Copper River rises in Copper Glacier, on the north slope of the Wrangell Mountains, and enters the Pacific Ocean about 150 miles (in an air line) to the south. Its principal tributaries, named in downstream order, are Slana, Chistochina, Gakona, Gulkana, Tazlina, Klutina, Tonsina, Tiekel, and Tasnuna rivers from the north and west, and Sanford, Klawasi, Nadina, Dadina, Chetaslina, Cheshnina, Kotsina, Chitina, and Bremner rivers from the east.

U. S. GEO



The source of the Copper is at an elevation of about 3,600 feet, making an average gradient for its entire course of about 12 feet to the mile. From Copper Center to the ocean there is a total fall of 1,000 feet, giving a mean fall of about 6.7 feet to the mile.

The topography of the basin is decidedly varied. The Wrangell Mountains occupy the northeastern portion of the basin and form its most conspicuous feature. The most prominent summits are Mount Sanford (16,208 feet), Mount Blackburn (16,140 feet), Mount Wrangell (14,905 feet), Mount Regal (13,400 feet), and Mount Drum (12,000 feet). The range is covered with a connected system of glaciers whose tentacle-like arms spread out from the many peaks and reach down at numerous points to elevations of 4,000 to 1,500 feet.

Within the plateau region, which it enters about 65 miles from its source, the Copper and its tributaries have cut deep channels varying from a few feet to 500 or 600 feet below the general plateau level. The plateau is made up largely of sand, gravel, and clay.

Soon after leaving the plateau region the Copper enters the Chugach Range and for the remainder of its course the flood plain reaches to steep mountain slopes on either side.

Chitina River, the largest tributary of the Copper, drains an area of 6,260 square miles. It rises in the St. Elias Range near the international boundary and flows northwestward for over 100 miles to the Copper. The largest tributaries of the Chitina enter from the north and emanate principally from the south slope of the Wrangell Mountains. Named in order downstream they are Nizina, Lakina, Gilahina, and Kuskulana rivers. The Chitina basin is bounded on the south by the Chugach Mountains, from which the main affluents are Tana, Chakina, and Tebay rivers.

The Copper River basin lies within two distinct climatic provinces. The northern part, including the Chitina River basin, though south of the Alaskan Range is similar to the interior region of Alaska, being separated from the Pacific coast province by the Chugach Mountains. The climate is characterized by a low precipitation of both rain and snow. The summers are pleasant with moderate temperatures and many clear days. The winters are nearly as rigorous as those of the Yukon basin farther north.

Below Chitina River the Copper traverses the Chugach Range and passes through rapidly changing climatic conditions. The precipitation increases, with heavy rainfall and many cloudy days in the summer and deep snow in the winter. The range in temperature is not nearly as great as in the upper basin.

The Copper River basin as a whole is but poorly timbered. Spruce is the principal species and occurs up to an altitude of 3,000 feet. Most of it is small and scrubby, though small stands of trees reaching diameters of 2 feet occur here and there along the Chitina and some of the tributaries of the Copper within the plateau region. There is practically no timber of commercial value along the Copper River valley below Chitina. Between Cordova and the delta of the Copper, near Eyak Lake, Eyak River, and Sheridan Glacier, there are good stands of spruce and hemlock which are estimated by the Forest Service to contain a total of 425,000,000 to 635,000,000 feet board measure.

STREAM FLOW.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made in 1913 in the Copper River basin. The numbers refer to Plate VI.

1. Copper River at Copper Center.
2. Copper River at Miles Glacier.
3. Klutina River at Copper Center.
4. Kotsina River near mouth.
5. Nizina River above Kennicott River.
6. Dan Creek above hydraulic plant.
7. White Creek above Jolly Gulch.
8. Chititu Creek below Rex Creek.
9. Rex Creek above hydraulic plant.
10. McCarthy Creek above Nikolai Creek.
11. McCarthy Creek near McCarthy.
12. Lakina River at railroad crossing.
13. Gilahina River at railroad crossing.
14. Chokosna River at railroad crossing.
15. Kuskulana River at railroad crossing.
16. Strelna Creek at railroad crossing.
17. Tsina River below Ptarmigan Creek.
18. Tsina River at mouth.
19. Tiekel River at mouth.
20. Ptarmigan Creek at upper canyon.
21. Ptarmigan Creek at lower canyon.
22. Stuart Creek at mouth.
23. Kanata River at mouth.

DAILY RECORDS.

Daily gage height, in feet, and turbidity (silica parts per million) of Copper River near Copper Center, Alaska, in 1913.

Day.	June.	July.		August.		September.		October.		November.	
	Gage height.	Gage height.	Turbidity.	Gage height.	Turbidity.	Gage height.	Turbidity.	Gage height.	Turbidity.	Gage height.	Turbidity.
1		17.6		19.5	1,500	15.2	350	14.3	150	13.0	120
2		17.4		18.7	1,500	15.0	250	14.3	110	13.0	130
3		17.4		18.1	1,500	15.0	180	14.2	150	13.0	130
4		17.6		17.6	800	14.8	200	14.2	110	12.8	130
5		18.0		17.4	800	14.7	200	14.1	130	12.8	120
6		18.6	1,500	17.3	500	14.6	180	14.0	130	12.8	120
7		18.5	900	17.2	800	14.5	180	14.0	130	12.8	110
8		18.4	800	17.0	800	14.4	200	13.8	130	12.7	110
9		18.1	600	16.8	600	14.3	180	13.6	130	12.6	110
10		17.8	600	16.7	500	14.2	180	13.6	130	12.6	110
11		17.8	600	16.6	800	14.1	180	13.4	110	12.6	100
12		17.6	500	16.3	500	14.0	180	13.3	110	12.6	100
13		17.4	350	16.2	500	14.0	180	13.4	110	12.6	85
14		17.3	400	16.2	500	13.9	180	13.6	130	12.7	95
15		17.3	400	16.1	800	13.9	110	14.0	130	12.8	85
16		17.4	500	15.9	600	13.9	100	13.8	150	12.7	85
17		17.2	500	15.8	500	13.8	110	13.7	150	12.6	100
18	16.7	17.0	500	15.6	500	13.8	110	13.6	150	12.8	95
19	17.0	16.9	350	15.6	500	13.7	130	13.4	150	12.6	100
20	17.0	16.5	300	15.8	350	13.7	100	13.6	150	12.5	95
21	16.8	16.5	400	16.0	500	13.7	100	13.5	150	12.5	95
22	16.7	16.4	300	16.1	800	13.7	100	13.5	130	12.5	80
23	17.0	16.6	350	16.0	800	13.7	120	13.5	130	12.5	85
24	17.8	16.8	350	16.2	800	14.0	110	13.4	130	12.6	80
25	18.1	17.3	400	16.5	800	14.4	150	13.2	130	12.6	85
26	18.0	18.4	1,500	16.7	800	14.5	250	13.3	120	12.5	85
27	18.1	19.0	3,000	16.6	600	14.4	200	13.2	120	12.6	80
28	17.7	19.8	3,000	16.5	500	14.4	110	13.0	120	12.8	75
29	17.9	20.4	3,000	16.1	500	14.4	200	13.0	120	12.8	90
30	17.8	20.2	3,000	15.8	350	14.8	150	12.9	120	13.0	95
31		20.1	3,000	15.6	250			13.0	150		

Daily discharge, in second-feet, of Copper River at Miles Glacier for 1913.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		186,000	142,000		40,100		16		216,000	78,700			
2				70,400			17				44,000		
3		197,000					18						
4					27,500		19			70,400	43,200		
5							20		128,000				
6		179,000	106,000	50,000			21				47,200		
7					27,500		22		127,000				
8		198,000					23		117,000	98,600	114,000		
9				40,100			24						
10		178,000					25				139,000		
11			113,000				26		142,000				
12						17,400	28		152,000	174,000			
13							28						
14							29	205,000	178,000		106,000		
15		192,000	82,600				30	208,000					
							31			82,600			

Daily discharge, in second-feet, of Klutina River and McCarthy Creek for 1913.

Day.	Klutina River at Copper Center. (Drainage area, 1,040 square miles.)					McCarthy Creek near McCarthy. (Drainage area, 71 square miles.)						
	June.	July.	Aug.	Sept.	Oct.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	......	7,300	3,960	3,160	2,070	......	......	427	170	91	170	......
2	......	7,060	3,960	2,860	2,070	......	......	485	174	90	154	......
3	......	7,060	3,720	2,770	2,010	......	......	495	210	91	139	37
4	......	6,820	3,720	2,510	1,950	......	......	544	210	84	93	......
5	......	6,820	3,720	2,430	1,950	......	......	544	226	83	76	24
6	......	6,820	3,720	2,280	1,830	......	......	465	437	......	91	......
7	......	6,820	3,720	2,200	1,720	......	......	437	362	......	76	......
8	......	7,300	3,720	2,070	1,720	......	539	344	418	......	44	......
9	......	7,300	3,600	1,950	1,580	......	519	326	451	......	76	......
10	......	6,820	3,720	1,830	1,440	......	389	282	380	......	37	......
11	......	6,820	3,720	1,830	1,350	......	353	250	226	......	37	......
12	......	6,820	3,840	1,780	1,350	......	418	218	218	......	37	......
13	......	6,820	3,840	1,720	1,310	......	654	242	210	......	......	......
14	......	6,820	3,720	1,620	1,270	......	700	266	154	......	......	......
15	......	6,820	3,720	1,620	1,200	......	684	254	145	......	......	......
16	......	6,600	3,490	1,580	1,170	......	654	230	151	......	......	......
17	4,660	6,370	3,270	1,530	1,170	......	564	238	151	......	......	......
18	4,660	6,160	3,160	1,480	1,140	......	664	202	170	......	......	......
19	4,820	5,750	3,060	1,480	1,140	......	798	151	174	......	......	......
20	5,000	5,550	3,060	1,440	1,140	......	504	134	158	......	......	......
21	5,000	5,360	3,060	1,400	1,140	......	634	145	186	61	......	......
22	5,000	5,170	3,060	1,350	1,140	......	669	206	186	63	......	......
23	5,170	5,000	3,060	1,620	1,140	......	777	206	202	480	......	......
24	5,170	4,820	3,270	1,830	1,140	......	876	250	170	624	......	......
25	5,550	4,820	3,380	1,890	1,140	......	644	226	167	485	......	......
26	5,950	4,820	3,490	2,070	1,140	......	609	258	158	451	......	......
27	6,820	4,820	3,490	2,070	1,140	......	574	437	161	290	......	......
28	7,060	4,820	3,600	2,140	1,140	......	504	242	158	......	......	......
29	7,300	4,510	3,490	2,140	1,010	191	519	246	151	574	......	......
30	7,300	4,090	3,490	2,140	1,080	......	446	226	97	210	......	......
31	......	3,960	3,380	......	1,050	......	......	186	97	......	......	......
Mean	5,680	6,030	3,520	1,960	1,390	......	595	296	211	......	85.8	......
Mean per square mile	5.46	5.80	3.39	1.88	1.34	......	8.38	4.17	2.97	......	1.21	......
Run-off (depth in inches on drainage area)	2.84	6.69	3.91	2.10	1.54	......	7.17	4.81	3.42	......	.54	......
Accuracy	C	C	C	C	D	......	A	A	A	......	A	......

MISCELLANEOUS MEASUREMENTS.

Miscellaneous measurements in Copper River drainage basin in 1913.

Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square mile.
			Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
Kotsina River	Copper River	Near mouth	200	447	0.45
Nizina River	Chitina River	Above Kennicott River.	492	865	.57
Dan Creek	Nizina River	Above hydraulic plant.	37	40	.92
While Creek	Chititu Creek	Above Jolly Gulch	14.1	9.4	1.50
Chititu Creek	Nizina River	Below Rex Creek	53	24	2.21
Rex Creek	Chititu Creek	Above hydralic plant.	18.4	9.5	1.94
McCarthy Creek	Kennicott River	Above Nikolai Creek.	21	48	.44
Lakina River	Chitina River	Railroad crossing	[a] 1,750	124	14.11
do	do	do	224	124	1.81
do	do	do	99	124	.80
Gilahina River	do	do	212	56	3.79
do	do	do	81	56	1.45
Chokosna River	Gilahina River	do	241	43	5.62
do	do	do	172	43	4.00
do	do	do	69	43	1.60
Kuskulana River	Chitina River	do	145	221	.66
do	do	do	603	221	2.73
do	do	do	[b] 500	221	2.26
do	do	do	130	221	.59
Strelna Creek	Kuskulana River	do	46	25	1.84
do	do	do	55	25	2.20
do	do	do	24	25	.96
do	do	do	3.3	25	.13
Tsina River	Tiekel River	Below Ptarmigan Creek.	87		
do	do	do	50		
do	do	Mouth	134	161	.83
Tiekel River	Copper River	do	5,820	408	14.3
do	do	do	8,480	408	20.8
do	do	do	819	408	2.01
Ptarmigan Creek	Tsina River	Below lake at head of upper canyon.	11.9	7.7	1.55
do	do	do	2.8	7.7	.36
do	do	2 miles above mouth at head of lower canyon.	22	16	1.38
do	do	do	23	16	1.44
Stuart Creek	do	Mouth	14.8		
do	do	do	8		
Kanata River	Tiekel River	do	146	175	.83
do	do	do	69	175	.39
Salmon Creek	Alaganik Slough	Below forks [c]	119		

[a] Float measurement. [b] Estimated. [c] See Pl. V.

WATER POWER.

topography of the Copper River basin is in many respects able for the development of water power. The Wrangell and ch mountains give a heavy grade and many waterfalls to the ns emanating from them. They also contribute a heavy stream n the summer due to the melting of glaciers and accumulated banks from the previous winter. Natural storage sites in the of lakes and ponds are not numerous, however, nor is the tunity for the creation of large storage basins by dams par- rly favorable.

the winter the run-off becomes very low and it is doubtful if of the Chugach Range the development of water power will be found practicable during that season. It is difficult without more data to make even an approximate statement regarding the period during which the flow of the streams and the temperature would permit the operation of a power plant in that region, but from the best information available it appears that the extreme limits of time for the successful operation of such a plant would be from about the first of May until the first of December. The same limits of operating time would also probably apply to the tributaries of the lower Copper unless considerable storage could be obtained.

The most natural sites for power development on the main Copper River are at Wood Canyon, about 6 miles below the Chitina, and at Abercrombie Rapids, about 10 miles above the delta. A head of 40 to 50 feet could probably be obtained at each locality, thus affording opportunity for producing between 4,500 and 5,700 theoretical horsepower for each 1,000 second-feet of flow. The lowest flow measured in 1913 at the gaging station at Miles Glacier bridge was 17,400 second-feet on November 12. That probably represented the minimum flow since about the middle of May of that year. The discharge at Wood Canyon on the same date was probably about 15,000 second-feet, as the drainage area here is about 15 per cent less than at the measuring section. The only inflow of consequence between the rapids and the measuring section is that from Miles Glacier. Both sites would be expensive to develop, and silt and ice would introduce serious operating problems. At the rapids the river is flanked on the east side by a moraine which might render the construction of stable headworks particularly difficult.

In the Chitina River basin good dam sites occur on many of the tributaries. Nizina and Kuskulana rivers flow through rock canyons in their lower stretches. It is estimated that 4,000 to 5,000 horsepower could be developed on the Nizina and at least 1,000 horsepower on the Kuskulana. Both sites would require high masonry dams, and provision would have to be made for passing immense quantities of silt, sand, and gravel. Power could be developed on McCarthy Creek and Lakina River by diverting the water to a conduit and carrying it down the valley a sufficient distance to obtain the desired pressure. McCarthy Creek has an average grade of about 100 feet to the mile and the Lakina about 70 feet to the mile. It is estimated that for each 100 feet fall at least 150 horsepower could be developed on the former stream and 500 horsepower on the latter. Tebay River falls over 1,000 feet between the Hanagita Valley and the Chitina, a distance of about 6 miles. There are several lakes in the headwater region which might afford considerable storage, but no measurements of flow have been made on the Tebay. Many smaller tributaries of the Chitina afford opportunity for the development of a few hundred horsepower.

Kotsina River and other branches of the Copper that head in the Wrangell Mountains also afford favorable sites for power development.

Klutina River has a grade of about 30 feet to the mile in its lower course. Its flow is regulated to a remarkable degree by Klutina Lake, which has an area of 51 square miles. The discharge on October 31, 1913 (see p. 166), was sufficient to develop about 80 horsepower for each foot of fall.

Of the lower Copper River tributaries the Tiekel is perhaps the principal power stream. It is formed by the union of Tsina and Kanata rivers. Between the forks and the Copper, a distance of about 15 miles, it falls about 750 feet. The flow on September 10, 1913, was sufficient to produce about 65 horsepower for each foot of fall. Natural dam sites occur on the Tsina. On Ptarmigan Creek, which is a tributary of the Tsina, there is a particularly favorable site at falls near the mouth for the development of a few hundred horsepower.

Besides the Tiekel there are many smaller branches of the Copper that flow from the Chugach Mountains on which power could be developed, but no measurements of flow have been made on these streams.

All stream-flow data that are available for this basin are shown in the tables already given. The estimates of power capacities are based on meager information and should be considered only roughly approximate. They apply only to the period from the beginning of the open season in May until about the first of November. As previously stated, it is doubtful if it would be practical to use water power in this basin after the first of December at the latest.

In the mountainous regions the transmission of electricity would be very difficult and expensive because of the heavy snowfall and steep, rocky slopes. High winds prevail in the lower Copper River valley and in many of the tributary valleys during much of the winter.

Most of the tributaries of the Copper head in glaciers and during the summer carry large quantities of sand and silt, which must be provided for in the construction of dams.

At the present time, with coal costing $8 to $12 or more a ton at the coast and crude oil at $2 a barrel, hydroelectric power would probably be much cheaper than steam, even though the plant could be operated but six or seven months in the year, but in view of the many difficulties in the way of developing water power, such as the short season and consequent necessity for auxiliary steam power, the great variation in stream flow, the costs of transmission, and the presence of silt and ice, it does not seem probable that large water-power plants will have much advantage over steam plants if the cost of fuel is reduced to as low a figure as should be expected when the Bering River coal fields are opened. In inaccessible regions where the costs of transportation would make fuel unduly expensive the small water powers will no doubt be of considerable value if energy is there needed for mining or other purposes.

PRINCE WILLIAM SOUND REGION.

GENERAL FEATURES.

Prince William Sound (see Pl. VII) is an irregular-shaped bay reaching northward from the head of the Gulf of Alaska. Along its shores there are gold and copper mines. The sound extends from Cordova on the east to the head of Passage Canal on the west, a distance of 102 miles. In a north-south direction it reaches from the head of College Fiord to the lower end of Montague Island, a distance of 104 miles. The entrance to the sound lies between Hinchinbrook and Montague islands. The shore line is broken by a succession of fiords, bays, and inlets, and many islands are scattered about the sound, particularly in its western part.

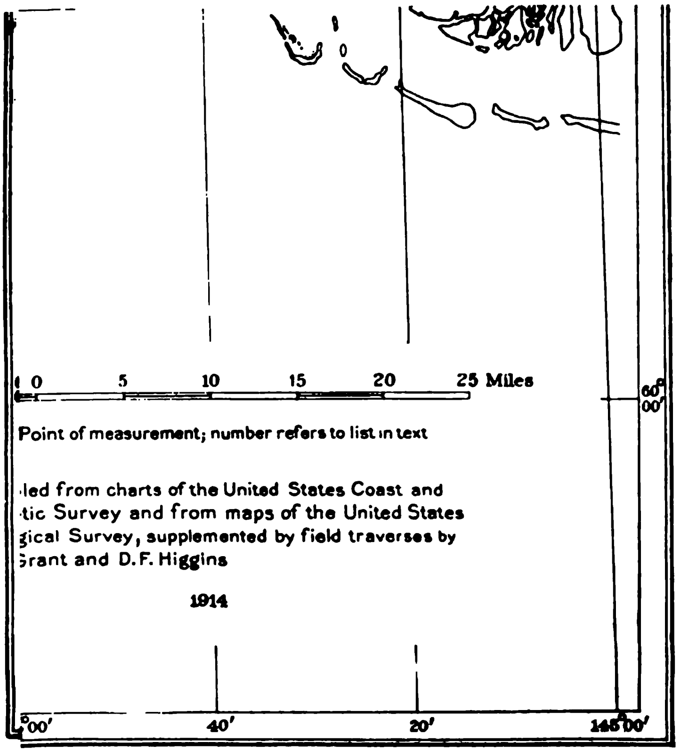
The topography of the mainland is particularly rugged. The coast is rocky and precipitous and rises rapidly to the summit of the Chugach Mountains, which nearly encircle the sound. Most of the higher valleys are occupied by glaciers, many of which extend down to sea level. The peaks near the coast are mostly from 2,000 to 5,000 feet in elevation. Farther north, toward the axis of the range, they reach altitudes of over 10,000 feet.

Grant and Higgins[1] state that "the topography of Prince William Sound is that of a maturely eroded mountainous district with the forms of river erosion modified by ice erosion. Into such a district the sea has come, filling the main basin of the sound and extending far up the valleys that lead into it."

The streams entering the sound drain small areas, and most of them are only from 1 to 5 miles long. Lowe River is probably the largest. It is 30 miles long and drains an area of less than 200 square miles. Practically without exception the streams rise in snow fields and glaciers. Their flow is subject to wide variations from summer to winter. The rapid melting of the glaciers and snow banks, together with a heavy rainfall in the summer, produces high rates of run-off. In the fall and winter the flow from the accumulated ice and snow in the mountains rapidly decreases, and the precipitation comes mostly in the form of snow. There is some rainfall and melting of snow during the winter, but the winter flow probably depends largely on the draining of underground channels. The prevailing rock forma-

---

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, p. 15, 1910.



Point of measurement; number refers to list in text

led from charts of the United States Coast and
tic Survey and from maps of the United States
gical Survey, supplemented by field traverses by
rant and D.F. Higgins

1914

tion is slate and graywacke with only a thin covering of soil and other loose material. The opportunity for underground storage is therefore likely to be slight, and such sources would as a rule become quickly exhausted as soon as the inflow from the surface was cut off by low temperature.

The mainland shores and most of the islands of Prince William Sound are generally covered with a thick growth of trees up to elevations of 1,000 feet or more. Spruce is the prevailing growth and some of it is of a size and quality to produce a good grade of sawed lumber. Much of it, however, is stunted and of an inferior quality. The United States Forest Service estimates that there is nearly 3,500,000,000 feet board measure of timber in the Prince William Sound region.

The principal use of the timber resources of this region will probably be for the production of wood pulp. The timber is said to be suitable for that purpose, and the possibilities for the successful introduction of the pulp industry have been considered, but so far as is known steps have not yet been taken toward the construction of mills. The manufacture of wood pulp has recently been commenced in southeastern Alaska where one small mill was being erected in the summer of 1913, and reports indicate that the extent of such operations will be increased in the near future.

The forests of Prince William Sound are all included in the Chugach National Forest, which is under the control of the Forest Service of the United States Department of Agriculture. The local administration of this forest is in charge of the forest supervisor at Ketchikan, who has a suboffice at Cordova. Such timber as it is considered advisable to cut within the forest will be sold by the Forest Service at a price not less than the appraised value. Lots exceeding $100 in value must be advertised for 30 days and sold to the highest bidder.

STREAM FLOW.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made on streams tributary to Prince William Sound in 1913. The numbers refer to Plate VII.

1. Salmon Creek below forks.[1]
2. Power Creek near Cordova.[2]
3. Humpback Creek near Cordova.
4. Snyder Falls Creek at mouth.
5. Wesley Falls Creek at elevation 600 feet.
6. Parsons Falls Creek at mouth.
7. Robinson Falls Creek at mouth.
8. Unnamed stream tributary to Sheep Bay.
9. Unnamed stream tributary to Port Fidalgo.
10. Unnamed stream tributary to Fish Bay.
11. Unnamed stream tributary to Fish Bay.
12. Chisna Creek at mouth.
13. Horsetail Falls Creek at mouth.
14. Lagoon Creek at mouth.
15. Reynolds Creek at elevation 250 feet.
16. Gladhaugh Creek at elevation 250 feet.
17. Gladhaugh Creek at elevation 125 feet.
18. Bottle Creek at mouth.
19. Duck River at mouth.
20. Solomon Gulch above upper dam.
21. Solomon Gulch at mouth.
22. Lowe River at lower end of Heiden Canyon.
23. Mineral Creek between Brevier and Glacier creeks.
24. Mineral Creek at lower canyon.
25. Brevier Creek at elevation 150 feet above that of mouth.
26. Glacier Creek at elevation 100 feet above that of mouth.
27. East Fork of Mineral Creek at elevation 900 feet above that of mouth.
28. Gold Creek above falls.
29. Gold Creek at mouth.
30. Uno Creek at mouth.
31. McAlister Creek at mouth.
32. Unnamed creek tributary to Eaglek Bay.
33. Dans Creek at Golden.
34. Avery River near Golden.
35. Lagoon Creek at lake outlet.
36. Hobs Creek at mouth.
37. Hummer Creek at mouth.
38. Unnamed creek tributary to Hummer Bay.

---

[1] Salmon Creek enters the Pacific Ocean east of Prince William Sound through Alaganik slough.

[2] Power Creek enters the Pacific Ocean east of Prince William Sound through Eyak Lake and Eyak River.

DAILY RECORDS.

Daily discharge, in second-feet, of Power and Humpback creeks for 1913.

Day.	Power Creek near Cordova.					Humpback Creek near Cordova.				
	July.	Aug.	Sept.	Oct.	Nov.	May.	June.	July.	Aug.	Sept.
1										
2							75			
3								85	48	
4										
5									55	
6								96		
7		433					75			
8		698						85		
9		[a]1,030		187					127	15.0
10		633	147	154	96					
11		496	147	149	106			75		
12		450	240	140	359					
13		441	314				73		40	
14		656	617		193					
15			638		132					
16								96	31	
17										
18									31	
19		311					71	169		
20		325				41		200		
21		336				41			31	
22		363								
23		351					75			
24		385						102		
25	418	393			240				31	
26	674	427							59	
27		[a]2,360				87				
28						76	75	51		
29								127	90	
30	496							108		
31	418									

[a] Approximate.

Daily discharge, in second-feet, of Duck River and Bottle Creek for 1913.

Day.	Duck River at Galena Bay.								Bottle Creek at Galena Bay. (Drainage area, 12 square miles.)			
	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	May.	June.	July.	Aug.
1		272					608			127	148	84
2		350	540		608					123	142	77
3				412			100			138	144	60
4						390		64		181	148	56
5		445	560		507					215	152	54
6				476			70			238	140	66
7		533								204	131	59
8			573		573					210	127	54
9										267	119	66
10		608		540				59		238	108	90
11			608							181	99	59
12	76		601	445		149	196			159	99	52
13	85	573			540				155	257	99	46
14									140	262	90	35
15			573	340					135	250	90	30
16	97	507				40	212	40	179	245	108	24
17		594							166	226	118	20
18				293					210	215	138	19
19	118		560			608	107		179	181	181	21
20		573					164	111	127	206	362	20
21	122			412					138	181	274	22
22			608		760				152	210	192	27
23	136					164			181	192	159	35
24		608		445					148	181	138	27
25			608				136		127	178	116	29
26	161								116	174	108	215
27		573		800					215	170	103	462
28	196					44		50	206	177	99	362
29			608				122		181	159	94	108
30		507			507				138	148	87	46
31			594						127		82	40
Mean									159	196	135	76.3
Mean per square mile									13.3	16.3	11.2	6.36
Run-off (depth in inches on drainage area)									9.40	18.2	12.9	7.33
Accuracy									B	B	B	B

Daily discharge, in second-feet, of Gladhaugh Creek at elevation 250 feet in 1913.

Date.	Discharge.	Date.	Discharge.
May 14	10.2	June 19	9.8
16	11.3	July 13	4.0
20	9.0	26	9.4
24	10.2	Aug. 2	2.4
31	13.3	Oct. 8	2.0
June 6	14.1		

Daily discharge, in second-feet, of Gold and Uno creeks for 1913.

Day.	Gold Creek near Valdez. (Elevation, 800 feet; drainage area, 9.5 square miles.)			Uno Creek at mouth, near Valdez. (Drainage area, 5 square miles.)				
	Sept.	Oct.	Nov.	May.	Aug.	Sept.	Oct.	Nov.
1	....	....	....	....	....	30	34	....
2	....	....	....	....	....	26	24	....
3	....	78	42	....	....	24	19.3	....
4	....	78	23	....	....	19.7	21	....
5	....	78	17.8	....	58	17.7	25	....
6	....	58	17.8	....	64	16.6	19.7	....
7	....	39	14.6	....	60	14.5	18.1	....
8	35	30	....	6.3	73	13.8	14.2	....
9	38	30	12.0	....	70	13.8	13.8	....
10	30	28	....	....	58	12.6	13.2	....
11	35	23	....	....	56	12.9	11.4	....
12	49	....	....	....	47	16.6	12.3	....
13	78	21	....	....	48	44	8.1	....
14	101	21	....	....	48	51	....	....
15	108	17.8	....	....	44	49	....	....
16	94	17.8	....	....	40	38	....	....
17	78	17.8	....	....	40	30	....	....
18	63	16.4	....	....	40	26	....	....
19	67	17.8	....	....	39	27	....	....
20	63	....	....	....	48	22	....	2.5
21	63	17.8	....	....	52	30	....	....
22	85	18.4	....	....	48	37	....	....
23	....	17.8	....	....	45	80	7.2	....
24	....	16.7	....	....	47	85	....	....
25	....	14.6	....	....	47	52	....	....
26	....	14.6	....	....	54	46	....	....
27	....	....	....	....	62	29	....	....
28	165	13.1	....	....	70	27	....	....
29	152	....	....	....	50	36	....	....
30	....	17.0	....	....	51	37	....	....
31	....	....	....	....	38	....	....	....
Mean		....	....	....	51.7	32.1	....	....
Mean per square mile		....	....	....	10.3	6.42	....	....
Run-off (depth in inches on drainage area)		....	....	....	10.3	7.16	....	....
Accuracy		....	....	....	C	C	....	....

Daily discharge, in second-feet, of Davis Creek, Avery River, and Hobo Creek for 1913.

Day.	Davis Creek at mouth, near Port Wells.					Avery River at mouth, near Port Wells.				Hobo Creek at mouth, near Port Wells.			
	Aug.	Sept.	Oct.	Nov.	Dec.	Aug.	Sept.	Oct.	Nov.	Aug.	Sept.	Oct.	Nov.
1	......	77	......	32	11.6	......	129	255	204	......	44	......	......
2	......	77	......	50	11.3	......	93	194	535	......	......	......	......
3	......	63	......	32	11.3	......	79	151	160	......	......	......	......
4	......	52	......	32	11.2	......	70	146	93	......	......	......	......
5	......	46	......	54	11.1	......	61	142	83	......	......	......	......
6	......	43	......	48	11.	......	64	104	67	......	......	......	......
7	172	42	......	45	11.2	199	64	93	58	......	......	......	......
8	270	40	......	39	11.	415	61	73	56	88	......	......	......
9	437	40	46	37	10.7	337	61	64	53	110	......	......	......
10	281	38	41	36	10.6	255	58	58	48	94	......	24	......
11	200	77	36	19.1	10.5	229	56	56	51	72	......	......	......
12	160	135	32	17.6	10.4	194	61	47	61	71	......	......	......
13	140	184	26	17	12.2	199	101	44	56	64	......	......	......
14	135	239	26	17	14.5	199	204	44	53	62	......	......	......
15	137	248	25	16.5	17.4	199	393	44	48	56	......	......	......
16	133	352	26	16.1	20	189	255	42	48	58	......	......	......
17	142	316	27	17.4	21	199	174	38	47	56	......	......	......
18	135	133	88	20	22	199	151	36	46	49	......	......	......
19	113	231	346	20	29	194	260	489	46	47	......	......	19.2
20	117	184	200	21	32	199	194	101	46	51	......	......	......
21	133	129	77	[a]21	33	309	133	120	48	52	......	......	......
22	151	396	226	20	32	255	315	271	46	54	......	......	......
23	155	664	197	19	28	229	999	112	46	52	......	......	......
24	146	......	95	18	21	421	912	104	45	52	......	......	......
25	184	......	67	17	21	365	622	73	44	52	......	......	......
26	242	......	48	16	21	229	371	58	44	58	......	......	......
27	504	......	45	15	20	744	229	56	46	119	......	......	......
28	418	......	43	14	19.6	315	250	48	58	104	......	......	......
29	189	......	41	13	19.1	204	371	73	53	102	......	......	......
30	146	......	21	[a]12	18.6	179	651	489	48	89	......	......	......
31	113	......	17.4	......	18.4	133	......	224	......	46	......	......	......
Mean	198	165	78.1	25.1	17.8	264	248	124	77.9	69.1	......	......	......
Accuracy	B	B	B	C	C	C	B	B	B	B	......	......	......

[a] Gage heights affected by ice Nov. 21-30. Discharges for that period interpolated.

MISCELLANEOUS MEASUREMENTS.

Miscellaneous measurements in Prince William Sound region in 1913.

Date.	Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square mile.
				Sec. ft.	*Sq. miles.*	*Sec. ft.*
July 29	Snyder Falls Creek.	Rude River	Mouth	99		
28	Wesley Falls Creek.	do	Elevation, 600 feet	79		
29	Parsons Falls Creek.	do	Mouth	[a] 150		
29	Robinson Falls Creek.	do	do	8.3		
July 30	Unnamed creek	Sheep Bay	Elevation, 700 feet	[a] 75		
Aug. 2	do	Port Fidalgo	Mouth	205		
2	Falls (?) Creek	Fish Bay	Below forks	70		
1	Unnamed creek	do	Elevation, 900 feet	3.7		
1	Chisna Creek	Landlock Bay	Mouth	4.2	0.9	4.67
1	Horsetail Falls Creek.	do	do	4.2	.7	6.00
July 31	Lagoon Creek	do	do	67		
Oct. 8	do	do	do	20		
Nov. 18	do	do	do	14.4		
July 31	Reynolds Creek	do	Elevation, 250 feet	12.7	1.2	10.58
Oct. 8	do	do	do	3.3	1.2	2.75
Nov. 18	do	do	do	2.4	1.2	2.00
Aug. 2	Gladhough Creek	Virgin Bay	Elevation, 125 feet	3.5	1.0	3.50
Oct. 8	do	do	do	2.9	1.0	2.90
Nov. 18	do	do	do	2.0	1.0	2.00
May 7	Solomon Gulch	Port Valdez	Elevation, 550 feet	12.7		
9	do	do	do	16.0		
Nov. 24	do	do	Mouth	[a] 35		
Oct. 17	Lowe River	do	Foot of Heiden Canyon.	92	[b] 50	1.82
24	Mineral Creek	do	Between Brevier and Glacier creeks, at elevation 650 feet.	26		
May 10	do	do	At lower canyon; elevation, 100 feet.	79	39	2.03
Oct. 24	do	do	do	74	39	1.90
Nov. 24	do	do	do	37	39	.95
Oct. 24	Brevier Creek	Mineral Creek	Elevation, 100 feet above that of mouth.	4.4	4.9	.90
24	Glacier Creek	do	Elevation, 150 feet above that of mouth.	2.0		
24	East Fork of Mineral Creek.	do	Elevation, 1,000 feet above that of mouth.	2.6	3.8	.68
Aug. 10	Gold Creek	Port Valdez	Elevation, 950 feet	202	9.0	22.40
May 8	do	do	Mouth	12.1	10.0	1.21
Nov. 24	do	do	do	6.5	10.0	.65
May 8	McAllister Creek	Shoup Bay	do	2.4	2.5	.96
Aug. 9	Unnamed Creek	Eaglek Bay	Above falls, at elevation 200 feet.	656		
Oct. 11	do	do	do	38		
Aug. 8	Lagoon Creek	Harrison Lagoon	At lake outlet; elevation, 300 feet.	83		
Nov. 20	do	do	do	9.0		
Aug. 8	Hummer Creek	Hummer Bay	Mouth	240		
8	Unnamed Creek	do	do	160		

[a] Estimated.

[b] Approximate.

WATER POWER POSSIBILITIES.

The water powers of Prince William Sound are as a rule small but widely distributed. In the northern part of the sound, from Cordova to Port Wells, which was examined in some detail, almost every bay or inlet has one or more tributary streams on which small water powers could be developed for six or eight months during the year.

The months of low-water flow are January to April, and during that time most of the streams reach a very low stage. There are but few streams on which more than 200 or 300 horsepower could be developed at minimum flow, and it is doubtful if there is a single stream on which a plant of over 1,000 horsepower could be operated continuously without storage. There are, however, numerous sites where small to medium-sized reservoirs could be created, and thus many of the streams could be made to yield at least a small output throughout the year. One of the most favorable sites for storage is at Silver Lake, on Duck River near Galena Bay. Nearly the entire run-off of this basin could probably be controlled by a dam at the outlet of the lake. The lake is situated between 1 and 2 miles from tidewater, at an elevation of about 250 feet. It is estimated that a uniform output of 4,000 to 5,000 horsepower might be obtained.

Power Creek, a tributary of Eyak Lake, offers the best opportunity for the development of water power near Cordova. About 300 feet head is available. The minimum flow for six months in the year is estimated to be not less than 75 second-feet. That would produce about 1,800 horsepower with an efficiency of 70 per cent at the wheel. At times during the remaining six months of the year the capacity might become 50 to 75 per cent less. Some storage could be obtained by a dam at the upper end of the gorge.

So far as is known to the writers there are between Cordova and Port Valdez no sites other than Silver Lake where sufficient storage could be created to permit the development of more than 100 to 200 horsepower at minimum flow in the winter. A possible exception to the above statement might be made for a stream entering the head of Fish Bay, sometimes known as Falls Creek. It heads in a large glacial cirque about 2 miles from the coast and falls almost vertically over an escarpment estimated to be between 1,500 and 2,000 feet in elevation. In view of the high pressure that could be obtained at this point it has been considered a relatively large power site. The discharge of the creek on August 2, 1913, at a point about a mile below the foot of the falls was approximately 40 second-feet. The streams were all at a high summer stage on that date. No measurements of flow have ever been made at the head of the falls, but it is believed that, considering the high elevation, the flow might become almost entirely shut off during the three or four months of coldest weather.

The principal streams entering Port Valdez on which power could be developed are Solomon Gulch, Lowe River, and Mineral, Gold, and Uno creeks. No reservoir sites of importance exist on any of these streams except Solomon Gulch, on which two hydroelectric plants with an aggregate rated capacity of about 700 horsepower have been installed. A total fall of about 500 feet is available and if all the storage that it would be practicable to create was utilized, possibly 1,000 horsepower could be developed at all seasons.

Lowe River is one of the largest streams entering Prince William Sound. Water could be diverted at the head of Heiden Canyon, and in a distance of about 6 miles a head of over 900 feet could be obtained. The drainage area above the canyon is about 30 square miles and ranges in elevation from 1,500 to 7,000 feet. From about the middle of May until October several thousand horsepower could no doubt be developed, but the high elevation of the basin might involve so great a decrease in run-off and temperature as to render it impracticable to operate during the winter.

A few hundred horsepower could be developed on the East Fork of Mineral Creek, on Gold Creek, and on Uno Creek from about the first of May until about the first of November, but for much of the remainder of the year the output would probably be less than 100 horsepower

No investigation was made of the water powers between Port Valdez and Port Wells except on an unnamed stream which enters the west side of Eaglek Bay. The stream drains a hanging valley in which are a series of small lakes and falls directly into salt water over a nearly vertical rock bluff about 200 feet high. There is a good dam site at the outlet of the lake, and probably sufficient storage could be created for 500 to 1,000 horsepower to be developed throughout the year.

Davis Creek and Avery River enter Port Wells near Golden post office. Both streams have small reservoir sites and concentrated fall near tidewater. On Davis Creek there is a fall of about 140 feet between Davis Lake and tidewater, a distance of about half a mile. With the storage that could be created by a dam at the outlet of the lake the flow would probably be sufficient to produce at least 300 horsepower at all seasons.

A fall of about 100 feet could be obtained on Avery River in a distance of about half a mile. The flow is considerably greater than that of Davis Creek, but less storage could be created and the power capacity during the winter might even be less than that of Davis Creek.

A small plant could be cheaply installed at the mouth of Lagoon Creek, on the west side of Port Wells. The creek falls about 300 feet in a distance of 1½ to 2 miles, and about 100 feet fall is concentrated in the last 500 feet of its course. A flow of 90 second-feet as measured at an elevation of 300 feet on November 20, 1913, would develop about 70 horsepower for each 100 feet fall. The flow during the winter would undoubtedly become much lower.

There are said to be several good water powers in the western part of the sound south of Port Wells, but no data regarding their size and accessibility are available.

The above estimates should be considered as only roughly approximate. More complete measurements of flow, particularly during the winter, should be made before final plans for developments are worked out.

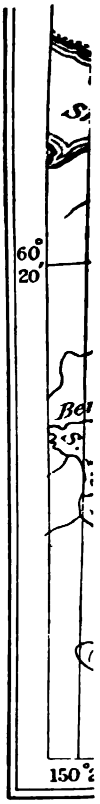
The transmission of electricity is one of the most serious difficulties that will be encountered in utilizing these water powers. Steep, rocky mountain slopes, dense growths of bush and trees, heavy snowfall and snowslides, glaciers, and broken shore lines are some of the obstacles to be overcome. Unless a market can be created for the power within a short distance of its source, it will probably never become of much value. There are, however, good harbor facilities in nearly all parts of the sound, so that ocean-going boats can be anchored within easy transmission distances from the powers. Submarine cable is now being manufactured that will carry electric current at a pressure of over 20,000 volts. Considerable cable with a capacity of 200 to 300 amperes for 11,000 volts working pressure has been used. Such cable, though expensive, might be practical for use in crossing narrow bays and inlets instead of running long land lines around them, or in reaching from island to mainland or from island to island. It might also be of service in crossing glaciers, where an overhead line would be very expensive to maintain.

The manufacture of wood pulp should offer a particularly suitable use for the water powers of this region, because of the fact that both the timber and the power sites are located near tidewater. It is claimed that pulp logs can be towed a distance of 150 to 200 miles at a permissible cost, thus eliminating the necessity of transmitting electricity for long distances to the mills. Any one water power in Prince William Sound would, under such conditions, be within reach of the entire timber supply.

KENAI PENINSULA.

GENERAL FEATURES.

Kenai Peninsula (see Pl. VIII) projects from the Alaska mainland into the north-central part of the Gulf of Alaska. It has an area of approximately 9,000 square miles, most of which lies between meridians 148° and 152° west longitude and parallels 59° and 61° north latitude. The peninsula is bounded by Prince William Sound on the east, the Pacific Ocean on the south, and Cook Inlet on the west. On the north it is joined to the mainland by a strip about 12 miles in width, which separates Portage Bay and Turnagain Arm. These bodies of water are arms of Prince William Sound and Cook Inlet, respectively. Kenai Peninsula has a shore line more than a thousand miles long. It contains gold placer and lode deposits.


60°
20'
150°

The surface of the peninsula presents two widely differing physiographic features. About three-fourths of its area, lying in the eastern, central, and southern parts, is occupied by the high, rugged Kenai Mountains, 5,000 to 7,000 feet in elevation, and valleys deeply cut by the action of the former ice sheet which covered the area and remnants of which are still found in the higher portions of the peninsula. The remaining fourth consists of a broad lowland about 25 miles wide, which slopes from an elevation of about 1,800 feet on the south, near Kachemak Bay, to an elevation of about 50 feet on the north.

The Kenai Mountain divide lies close to the eastern and southeastern side of the peninsula, so that the drainage flows principally toward the west and north and the streams flowing into the Pacific Ocean and Prince William Sound are short. The largest of the streams on the southeast side is Resurrection River, which is about 25 miles in length, drains an area southwest of Kenai Lake, and flows through a wide gravel-floored valley into the head of Resurrection Bay. Kenai River, the largest stream on the peninsula, drains its entire central portion and discharges into Cook Inlet at Kenai. Its drainage area includes two large lakes, Skilak and Kenai, and also numerous smaller ones on its upper tributaries. Kasilof River drains Tustumena Lake and enters Cook Inlet a short distance south of Kenai. Tustumena Lake is about 22 miles long and averages 6 miles in width. It is fed by several streams, some of which have their sources in the large glaciers in the Kenai Mountains. Two small streams, Chickaloon and Big Indian rivers, drain a portion of the Kenai lowland and discharge into Chickaloon Bay near the west end of Turnagain Arm. The principal streams entering Turnagain Arm from the mountainous area of the peninsula are Resurrection and Sixmile creeks and Placer River.

The fact that streams draining areas of rugged mountainous relief have steep gradients and waterfalls makes it obvious that the eastern portion of the peninsula would afford much more favorable opportunities for the development of water power than the western portion. Moreover, gold mining, which is the most important industry of the peninsula and which at this time presents the most promising market for water power, is confined to the mountainous area. The investigation of the water supply of the peninsula was carried on only in its eastern portion.

Kenai Peninsula is heavily timbered in most of its valleys up to elevations of 1,200 to 1,500 feet above sea level. Spruce is the most plentiful variety and the most valuable for commercial uses, but hemlock, poplar, birch, cottonwood, willow, and alders are found in some localities. Timber suitable for fuel is abundant below altitudes of 1,500 feet, but the supply that is valuable for saw logs is limited to small areas below 1,000 feet in elevation.

STREAM FLOW.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made on streams in Kenai Peninsula in 1913. The numbers refer to Plate VIII.

1. Lowell Creek above pipe intake.
2. Lowell Creek at mouth.
3. Kenai Lake at Roosevelt.
4. Kenai River at Kenai Dredging Co.'s camp.
5. Ptarmigan Creek at lake outlet.
6. Ptarmigan Creek at mouth.
7. Falls Creek at intake of Skeen-Lechner ditch.
8. Falls Creek at railroad crossing.
9. Grant Creek at mouth.
10. Quartz Creek at Fairman's cabin.
11. Lost Creek 3 miles below lake outlet.
12. Juneau Creek at mouth.
13. Stetson Creek at mouth.
14. Cooper Creek above Stetson Creek.
15. Cooper Creek at mouth.
16. Russian River one-fourth mile below lower lake outlet.
17. Russian River at mouth.
18. Canyon Creek above Mills Creek.
19. Sixmile Creek at Sunrise.
20. Mills Creek 2 miles above mouth.
21. Juneau Creek above upper ditch intake.
22. Resurrection Creek above Gold Gulch.

DAILY RECORDS.

Gage height of Kenai Lake, 1913, and discharge of Kenai River, 1913–14.

ay.	Daily gage height, in feet, of Kenai Lake at Roosevelt for 1913.					Daily discharge, in second-feet, of Kenai River at Kenai Dredging Co.'s camp for 1913–14.					
	Aug.	Sept.	Oct.	Nov.	Dec.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
		8.67	9.25	7.08			4,280	5,040	1,920	1,070	740
		8.36	9.06	7.42			3,960	4,900	2,160	1,070	740
		8.30	8.96	7.38			3,640	4,760	2,300	1,120	740
		8.12	8.85	7.33			3,640	4,480	2,300	1,160	820
		7.90	8.71	7.35			3,320	4,340	2,440	1,160	820
		7.66	8.58	7.32			3,160	4,200	2,440	1,160	740
		7.62	8.29	7.26			3,000	3,780	2,440	1,160	660
		7.53	8.12	7.16			2,720	3,500	2,160	1,160	580
		7.44	7.98	7.01			2,860	3,360	2,160	1,120	504
		7.34	7.80	6.82			2,160	3,090	2,040	1,070	580
		7.24		6.73			2,320	2,800	1,920	1,070	580
		7.19		6.71			2,320	2,600	1,920	980	504
		7.14		6.68			2,200	2,400	1,920	980	504
		7.04	7.16	6.66			2,080	2,320	1,800	940	504
		6.88	7.09	6.65	5.03		1,960	2,200	1,800	900	504
		6.90	6.98	6.63			1,960	2,080	1,800	900	542
		6.82	6.95	6.60			1,850	2,080	1,680	900	660
	8.89	6.78	6.95	6.53		4,620	1,850	2,080	1,560	900	580
	8.81	6.73	6.91	6.48		4,620	1,740	1,960	1,560	940	542
	8.82	6.69	6.86	6.41		4,620	1,740	1,960	1,460	1,020	504
	8.88	6.89	6.83	6.40		4,620	1,960	1,850	1,460	1,020	504
	9.02	7.24	6.77	6.32		4,620	2,320	1,850	1,410	980	504
	9.08	7.40	6.72	6.26		4,980	2,570	1,740	1,360	1,070	504
	9.14	7.64	6.60	6.09		4,980	2,830	1,800	1,360	1,070	504
	9.14	8.62	6.53	6.00		4,980	4,200	1,510	1,360	980	504
	9.12	9.34	6.49	5.93		4,980	5,180	1,560	1,260	980	580
	9.13	9.90	6.41	5.90		5,160	6,070	1,560	1,160	900	580
	9.15	9.90	6.35	5.79		5,160	6,070	1,560	1,160	900	504
	9.09	9.78	6.32	5.72		4,980	6,070	1,560	1,160	900	504
	8.80	9.63	6.52	5.66		4,620	5,620	1,920	1,070	820	504
	8.72		6.81			4,440		1,920		820	504
						4,810	3,190	2,670	2,050	1,010	582
mum						5,160	6,070	5,040	2,440	1,160	820
num						4,440	1,740	1,510	1,070	820	504
off in acre-feet						134,000	190,000	164,000	122,000	62,100	35,800
racy						B	B	B	B	C	C

Daily discharge, in second-feet, of Falls and Quartz creeks and Russian River for 1913.

Day.	Falls Creek [a] at railroad crossing near Roosevelt. (Drainage area, 15 square miles.)				Quartz Creek [b] at Fairman's cabin. (Drainage area, 30 square miles.)				Russian River [c] at mouth. (Drainage area, 60 square miles.)		
	Aug.	Sept.	Oct.	Nov.	Aug.	Sept.	Oct.	Nov.	Aug.	Sept.	Oct.
1	......	34	38	23	......	66	72	66	......	115	260
2	......	34	20	15	......	63	66	61	......	110	235
3	......	30	34	13	......	61	66	56	......	105	225
4	......	20	34	15	......	56	78	56	......	95	250
5	......	20	42	14	......	54	78	55	......	85	288
6	......	20	34	13	......	55	72	52	......	78	266
7	......	20	30	10	......	54	66	52	......	78	240
8	......	18	26	......	......	50	66	......	......	78	225
9	......	15	25	......	......	50	64	......	......	75	225
10	......	14	23	......	......	48	61	......	......	70	225
11	......	13	26	......	......	48	56	......	......	65	200
12	......	13	24	......	......	48	52	......	......	62	200
13	......	11	22	......	......	48	52	......	......	60	175
14	......	11	20	......	......	48	52	......	......	57	175
15	......	11	20	......	......	48	52	......	......	57	150
16	......	9	18	......	......	46	52	......	......	57	150
17	52	15	18	......	......	46	54	......	......	57	125
18	52	13	16	......	......	44	48	......	......	57	125
19	50	14	16	......	......	44	56	......	......	57	125
20	50	15	16	......	......	44	54	......	120	57	100
21	60	15	18	......	......	44	50	......	124	57	100
22	70	20	18	......	......	44	48	......	136	57	96
23	72	86	11	......	......	78	48	......	152	75	94
24	69	173	11	......	82	135	48	......	144	152	94
25	72	312	10	......	82	135	46	......	132	384	90
26	62	130	10	......	78	117	46	......	132	510	90
27	62	74	10	......	85	108	48	......	132	489	90
28	52	57	10	......	92	92	48	......	128	412	88
29	52	47	20	......	85	85	44	......	124	340	88
30	42	42	42	......	82	78	66	......	120	282	182
31	38	......	26	......	66	......	72	......	115	......	180
Mean	57.0	43.5	22.2	14.7	81.5	64.6	57.5	56.9	130	141	166
Mean per square mile	3.80	2.90	1.48	.980	2.72	2.15	1.92	1.90	2.17	2.35	2.77
Run-off (depth in inches on drainage area)	2.12	3.24	1.71	.26	.81	2.40	2.21	.49	.97	2.62	3.19
Accuracy	B	C	C	B	B	B	B	B	B	B	C

[a] The gage heights were affected by ice Oct. 13–20 and 26–29. Discharges are estimated for those periods.
[b] The gage heights were affected by ice Oct. 12–15 and 27. Discharges are estimated for those periods.
[c] Discharges interpolated Aug. 29 and 31; Sept. 1–2, 4, 9–10, 12–13, and 20; Oct. 4, 9–21, 23–28, and 31.

Daily discharge, in second-feet, of Sixmile and Mills creeks for 1913.

Day.	Sixmile Creek[a] at mouth. (Drainage area, 258 square miles.)				Mills Creek[b] 2 miles above mouth. (Drainage area, 25 square miles.)			
	Aug.	Sept.	Oct.	Nov.	Aug.	Sept.	Oct.	Nov.
1	....	780	970	1,020	....	94	87	51
2	....	700	970	780	....	87	87	43
3	....	665	825	700	....	81	75	....
4	....	630	970	665	....	75	87	....
5	....	600	920	600	....	75	87	....
6	....	600	825	570	....	69	101	....
7	....	570	780	545	....	69	73	....
8	....	570	740	495	....	63	67	....
9	....	545	665	545	....	61	63	....
10	....	545	630	600	....	61	55	....
11	....	520	570	570	....	58	55	....
12	....	520	570	495	....	55	55	....
13	....	520	520	470	....	58	55	....
14	....	520	495	470	....	53	50	....
15	....	545	520	450	....	53	50	....
16	....	545	520	430	....	53	45	....
17	....	545	520	450	....	53	45	....
18	....	545	495	450	....	53	45	....
19	....	600	570	450	....	56	45	....
20	....	630	520	450	....	53	50	....
21	....	570	495	450	....	53	62	....
22	....	630	495	430	....	56	53	....
23	....	825	495	430	....	108	51	....
24	....	1,420	470	430	....	143	48	....
25	....	5,000	470	430	143	203	46	....
26	....	2,220	430	430	136	187	45	....
27	1,590	1,420	545	430	157	129	45	....
28	1,270	1,140	545	400	136	101	45	....
29	1,020	970	470	400	115	101	45	....
30	920	1,020	1,500	400	108	101	87	....
31	870	....	970	....	101	....	58	....
Mean	1,130	897	661	514	128	82.1	60.1	....
Mean per square mile	4.38	3.48	2.56	1.99	5.12	3.28	2.40	....
Run-off (depth in inches on drainage area)	.81	3.88	2.95	2.22	1.33	3.06	2.77	....
Accuracy	A	A	A	A	C	C	C	....

---

[a] The gage heights were affected by ice Nov. 17–30. Discharges for that period are estimated.

[b] The gage heights were affected by ice Oct. 12–20 and 26–28. Discharges are estimated for those periods.

MISCELLANEOUS MEASUREMENTS.

Miscellaneous measurements on Kenai Peninsula in 1913.

Date.	Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square mile.
				Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
Aug. 15	Lowell Creek	Resurrection Bay	Above pipe intake	58		
Oct. 28	do	do	do	18.8		
28	do	do	Mouth	9.3		
Aug. 16	Ptarmigan Creek	Kenai Lake	500 feet below lake outlet.	156		
Oct. 10	do	do	do	95		
11	do	do	Mouth	92		
20	do	do	do	71		
Aug. 17	Falls Creek	Trail Creek	Intake of Skeen-Lechner ditch.	[a] 35		
Oct. 10	do	do	do	[a] 14.3		
9	Grant Creek	do	Mouth	155		
18	do	do	do	84		
17	Lost Creek	Kenai River	3 miles below lake	61	22	2.79
6	Juneau Creek	do	Mouth	103	63	1.63
24	do	do	do	58	63	.92
Aug. 21	Stetson Creek	Cooper Creek	do	35	8.0	4.39
21	Cooper Creek	Kenai River	Above Stetson Creek.	137	35	3.91
Oct. 6	do	do	Mouth	210	47	4.47
24	do	do	do	104	47	2.21
Aug. 20	Russian River	do	Lower lake outlet	132	55	2.40
25	Canyon Creek	Sixmile Creek	Above Mills Creek	[b] 90	28	3.21
Sept. 4	do	do	do	[b] 60	28	2.13
Oct. 14	do	do	do	44	28	1.56
Aug. 25	Juneau Creek	Mills Creek	Above upper ditch intake.	23	4.4	5.23
Sept. 23	Resurrection Creek.	Turnagain Arm	Above Gold Gulch	120	105	1.14

[a] Includes flow of ditch. [b] Includes flow of ditch diverting from Fresno Creek.

WATER POWER.

The topography of the mountainous area of Kenai Peninsula, in common with that of most of the Alaskan coast, is favorable for the development of water power. The water supply, as determined principally by the climate and the character and distribution of precipitation, is large and fluctuates widely in summer; in the winter it is much reduced. Usually the minimum flow of a stream determines the magnitude of the development which should be made upon it. Therefore it is of advantage if the stream has natural storage or if artificial storage can be provided, for thereby the minimum flow on a given stream can be increased and the possible capacity of the plant made greater. There are many streams which would furnish sufficient water from May 1 to October 31 for plants of 1,000 to 2,000 horsepower, depending upon the minimum flow alone, but there are few, if any, streams whose flow in the other six months of the year would be adequate for the development of more than a few hundred horsepower without storage. Except in the Kenai Valley few locations exist where artificial development of storage is possible. If winter power were demanded in excess of what could be obtained from the natural flow of the streams, it would have to be supplied from some other source.

The several lakes of the Kenai Valley have some tendency to regulate the flow of the streams rising in them, and the possibility of developing more storage upon them furnishes a means for increasing this regulatory effect. Dams could be constructed at any of the lake outlets, and the sites at some of them are exceptionally favorable. It seems probable that dams could be constructed on Ptarmigan and Grant lakes at a reasonable expense which would hold in reservoirs nearly the entire annual run-off from their respective tributary drainage areas. Thus the available power of the streams could be used at nearly a constant rate throughout the year, or it could be drawn upon as desired. If winter power is desirable and if the necessary expense is justified, the advantage of such a water supply over one obtained from the natural flow of a stream is obvious.

Kenai River falls approximately 310 feet between Kenai and Skilak lakes, and the fall is distributed about as follows: 60 feet from the outlet of the lake to the Kenai Dredging Co.'s camp, a distance of about 3½ miles; 70 feet from the camp to Russian River, a distance of 3 miles; and 180 feet in the remaining 9½ miles. There are no falls on Kenai River, and rowboats pass down it safely at ordinary stages, but the grade is concentrated in rapid stretches where the current is relatively swift. The discharge has been estimated from August 18, 1913, to January 31, 1914. The minimum flow for that period was 504 second-feet, and the average flow for the three following months would probably be considerably less. The estimated discharge would develop about 40 horsepower for each foot of fall with an efficiency of 70 per cent at the wheel.

Ptarmigan and Grant creeks probably offer the best power sites on Kenai Peninsula. A head of about 300 feet is available on Ptarmigan Creek and about 215 feet on Grant Creek. It is thought that by constructing storage dams at least 1,000 horsepower could be developed throughout the year on Ptarmigan Creek and 1,500 horsepower on Grant Creek.

Other streams on which reservoir sites of smaller capacities exist are Lost Creek, Cooper Creek, and Russian River, on which heads of 800 feet, 500 feet, and 170 feet, respectively, could be obtained. It is estimated from the measurements of flow that from about the first of May until the first of November from 500 to 1,000 horsepower could be developed on each of these streams. How much storage could be obtained is unknown, but it would probably not be sufficient to assure continuous winter operation of plants of more than 400 to 500 horsepower.

There are many other streams in the eastern part of Kenai Peninsula that would afford good opportunities for the operation of plants of various capacities less than 1,000 horsepower for six or seven months in the year, but the general lack of reservoir sites makes them of considerably less importance for winter operations than those already noted. The above estimates are only roughly approximate and are intended to give only a general idea of the water-power conditions. More extended and complete records of stream flow and surveys of reservoir sites should be available before final plans for development are made.

The proposition of connecting the possible water-power developments of this valley into a single hydroelectric system is not here considered in detail. The available data are far too inadequate for reaching conclusions as to its feasibility, which could be determined only by extensive survey and studies of the water supply. The most important power sites in this valley lie within a radius of 15 miles. If storage were fully developed and power plants installed where practicable, their interconnection by electric transmission lines would furnish means for obtaining the maximum output of power from the available water supply and its most uniform distribution through the year. It seems most probable that any market for power which is likely to arise in this region would demand continuous power. The primary purpose of the reservoirs would be to replenish the flow and hence the power output of the period from November 1 to April 30. Any water in excess of this requirement could be utilized for increasing the uniformity of the flow if that were desired. The run-off available at the various plants, the amount of storage, and the potential value of the water stored in the different reservoirs, as determined by the head through which it would act, would be the principal factors in determining the procedure in the operation of the plants or the release of water from the reservoirs. It seems probable that even with storage reservoirs developed to their utmost capacity the power output in summer could considerably exceed that of the winter. The construction, operation, and maintenance of eight or ten power plants, such as this proposition would involve, would probably make the cost for the power so great as to exclude it from the class of cheap power, and only a great growth of industry in this region would warrant such a development. On the other hand, there are no serious difficulties in the construction required and the region is easily accessible. Plans for extensive water-power development should take cognizance of the fact that there are large deposits of lignitic coal in the western half of the peninsula that might be used in generating power.

WILLOW CREEK DISTRICT.

GENERAL FEATURES.

The Willow Creek district (see fig. 2) is the area which includes the gold fields lying about 20 miles northeast of Knik, a settlement on Knik Arm of Cook Inlet. The district contains about 90 square miles and contains the divide between Little Susitna River and the South Fork of Willow Creek, a tributary of Susitna River. This divide is the southwestern extension of the Talkeetna Range. The center of the district is at about 149° 20′ west longitude and 61° 40′ north latitude.

The topography of the district is varied, the surface forms ranging from the steep, craggy mountains in the northern part to the much less rugged ridge known as Bald Mountain in the southern part. Several of the peaks exceed 5,000 feet in elevation. The valleys are V-shaped glacial troughs ranging in elevation from 1,500 to 3,500 feet. High in these valleys the slopes are heavily strewn with coarse glacial débris, broken rock, and talus. The large proportion of void spaces in this material affords an excellent reservoir of the summer water supply. Ice forms in them during the winter and by gradual thawing in the summer is an important factor in the distribution

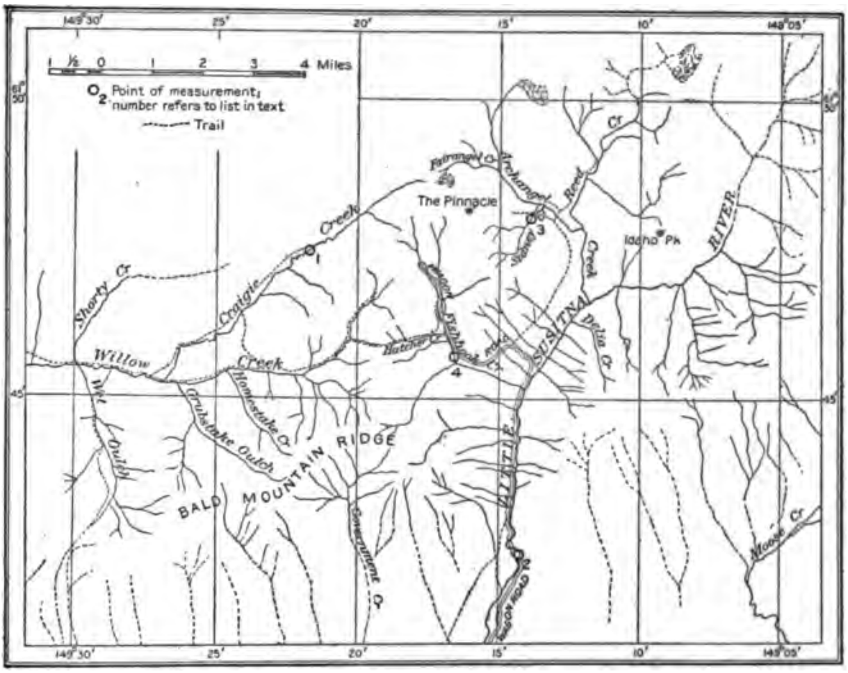


FIGURE 2.—Map of the Willow Creek district.

of stream flow at a time when it is of commercial value for the development of water power for the quartz mills. Practically all snow disappears from the district during the summer. There are scattered small glaciers at the head of Archangel Creek and one larger one at the head of the main branch of Little Susitna River.

A feature of the Willow Creek district which is of considerable economic significance is the scarcity of timber suitable either for fuel or for building. The lumber supply is plentiful and good in the lower parts of the valleys of Willow Creek and Little Susitna River, but on the former it does not extend above Wet Gulch and on the latter above a point about 2 miles below the mouth of Fishhook Creek. Alders and willows fringe the mountain sides to a considerably higher elevation, but they stop some distance below the quartz mills. Mining timber and wood for fuel must be hauled from 4 to 8 miles up steep grades. This increases the cost of the wood to a degree which almost prohibits its use for fuel.

STREAM FLOW.

GAGING STATIONS AND MEASURING POINTS.

The following list gives the locations at which gaging stations were maintained or discharge measurements made on streams in the Willow Creek district in 1913. The numbers refer to figure 2.

1. Craigie Creek at Gold Bullion mill.
2. Little Susitna River at mile 28.
3. Sidney Creek at lake outlet.
4. Fishhook Creek at mile 33½.

DAILY RECORDS AND MISCELLANEOUS MEASUREMENTS.

Daily discharge, in second-feet, of Craigie Creek at Gold Bullion mill for 1913.

[Drainage area, 2.8 square miles.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	18	20	11	12	21	34	14	16	3.8
2	18	24	10	11	22	40	16	12	10
3	25	26	10	9.8	23	40	14	11	44
4	32	30	10	8.6	24	39	14	10	26
5	37	28	9.6	7.8	25	34	14	11	16
6	40	26	14	7.0	26	31	20	23	7.1
7	42	22	12	6.4	27	36	18	46	4.2
8	47	22	12	6.0	28	34	18	24	3.7
9	53	22	11	5.6	29	25	15	18	3.7
10	47	24	11	5.3	30	18	12	12	7.6
					31	....	12	15	....
11	36	40	10	5.0					
12	38	24	9.2	4.2	Mean	38.4	20.1	13.7	8.32
13	42	28	9.0	4.0					
14	45	22	8.0	4.2	Mean per square mile	13.7	7.18	4.89	2.97
15	54	18	7.4	4.6					
16	55	16	4.4	4.5	Run-off (depth in inches on drainage area)	15.29	8.28	5.64	3.31
17	53	16	6.6	4.9	Accuracy	B	B	B	B
18	51	14	7.8	4.6					
19	49	12	26	4.2					
20	41	22	26	3.9					

NOTE.—These discharges were computed from weir records furnished by the Gold Bullion Mining Co.

Miscellaneous measurements in the Willow Creek district in 1913.

Date.	Stream.	Tributary to—	Locality.	Discharge.	Drainage area.	Discharge per square mile.
				Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
Sept. 10	Little Susitna River.	Cook Inlet	Mile 28	141	61	2.31
13	do	do	do	135	61	2.21
12	Sidney Creek	Archangel Creek	Lake outlet	1.88	1.1	1.71
12	Fishhook Creek	Little Susitna River.	Mile 33½	12.6	4.7	2.68

WATER POWER.

Up to the present time the only water-power developments which have been justified by the ore prospects of the Willow Creek region have been those situated directly at the mill sites, from the water supply available at those points. These mill sites are so far up the streams that the tributary drainage areas are too small to furnish the necessary supply for even the present small plants in dry seasons. Consequently the plants must be partly or wholly shut down at these times or the water power must be supplemented from other sources. The cost of auxiliary power in these inaccessible regions is so great as to be prohibitive unless the ore is very rich. At one of the mills it was stated that wood cost $40 a cord and that gasoline, which was there used, cost 70 cents a gallon at the mill. The development of water power in winter is impossible on these sites.

The easiest method of supplying the deficient power is by increasing the effective head at the plants. This can usually be accomplished easily, for the streams have heavy grades and much head can be obtained in comparatively short distances. In such a development there would usually be a small flow of water acting under a high head. Wheels for such installations as would be desired in this region are not carried in the regular stock of water-wheel manufacturers, but it is believed that if the conditions under which they were to operate were known, specially designed wheels could be procured which would give good results.

Another method of solving the power problem is to develop electric power on the lower stretches of the streams where the flow is larger and more dependable and transmit it to the property. A scheme has already been proposed for the mining companies of the region to cooperate in the development of hydroelectric power on Little Susitna River for their common use. In the vicinity of the mouth of Fishhook Creek the Little Susitna has a fall of about 150 feet to the mile. The valley in this portion varies from a U-shaped glacial trough to a narrow rock canyon and is everywhere filled with heavy granite bowlders. Concentrated fall and favorable topography make some locations better for power development than others. The most suitable type of development is probably a diversion dam, built only high enough to divert the required amount of water, and a combination of canal and pipe line for carrying it to the wheel.

The flow of the Little Susitna for six or seven months of the year under the head that it is possible to utilize would probably be ample for any power requirements that are likely to arise in this district. The discharge on September 13 at mile 28 was 135 second-feet, or 2.21 second-feet to the square mile. That flow would develop about 11 horsepower for each foot of fall, with an efficiency of 70 per cent at the wheel. With a flow of 0.5 second-foot to the square mile about 2.4 horsepower could be produced for every foot of fall.

Little is known of the winter flow of these streams, but to judge from the climatic conditions which prevail in this region it must fall to a very low stage. If winter operation was desirable and the stream flow was not found to be sufficient to provide the power, the closeness of the Matanuska coal fields affords a possible solution of the problem. When these coal fields are developed it should be possible to obtain at a comparatively low figure fuel for an auxiliary steam plant operating in conjunction with the hydroelectric plant.

Such a plant as is suggested would involve considerable expense, but there can be no question that it would have many offsetting advantages. The feasibility of the proposition depends on the future promise of the mining industry in the region. If the ore deposits are sufficiently large the outlay would be justified.

Except that it is more remote from the coal fields, a hydroelectric power could be generated on the lower part of Willow Creek quite as well as on the Little Susitna if the location of a central power plant in that vicinity should promise to be more convenient.

DEVELOPED WATER POWERS.

Controller Bay region.—No water power has been developed in the Controller Bay region.

Copper River basin.—A plant of 17-kilowatt capacity is used by the Great Northern Development Co. in connection with the development of its copper property. Possibly one or two other small plants have been installed in the Copper River basin.

Prince William Sound region.—The Cordova Power Co. has a plant on Humpback Creek, with a maximum capacity of 200 horsepower. The energy is used for light and power at Cordova.

The sawmill at Cordova uses three wheels with an aggregate capacity of about 150 horsepower.

The Northwestern Fishing Co. has one 36-inch and two 16-inch Pelton wheels at the Orca cannery; the operating head is 240 feet.

The Galena Bay Mining Co. has a plant on Bottle Creek, with a maximum capacity of 150 horsepower. This plant has been idle for several years, but was originally used in the development of a copper property.

The Alaska Water, Light & Telephone Co. and the Valdez Electric Co. have plants on Solomon Gulch, and the capacity of each is about 350 horsepower. The energy is used for light and power at Valdez.

A plant having a capacity of about 50 horsepower was installed on Glacier Creek, a small tributary of Mineral Creek, in the summer of 1913. The power will be used to operate a small stamp mill.

The Sea Coast Mining Co. began the construction of a plant on Uno Creek in 1913. A wheel capacity of 290 horsepower is contemplated.

A small sawmill was being operated at the mouth of Avery River by an overshot water wheel in the fall of 1913.

It is understood that a small water-power plant has been in operation on Latouche Island for several years, but no further information is available regarding it.

The capacity of most of these plants is undoubtedly considerably less during the winter months than that given.

Kenai Peninsula.—The only water-power plants on Kenai Peninsula, so far as is known to the writers, are that of the Seward Light & Power Co., which has a capacity of 150 horsepower and furnishes light and power for the town of Seward, and that of the Skeen-Lechner Mining Co. on Falls Creek, which develops about 75 horsepower and is used to operate a small stamp mill.

Willow Creek district.—Three water-power plants have been installed in the Willow Creek district for the operation of gold quartz mills. The Alaska Gold Quartz Mining Co. develops 15 to 20 horsepower on Fishhook Creek by a Pelton wheel under a head of 120 feet and uses the power to operate a 4-stamp mill. The Alaska Free Gold Mining Co. develops about 25 horsepower on Fishhook Creek by a Pelton wheel under a head of 35 feet and uses the power to operate a Lane mill. The Gold Bullion Mining Co. develops about 25 horsepower on Craigie Creek by a turbine wheel under a 28-foot head and uses the power to operate a 7-stamp mill. The water supply for these plants is sufficient for their operation only about three or four months during the summer.

Total development.—The maximum aggregate capacity of all water-power plants that were in operation in 1913 in the areas considered in this report was less than 2,000 horsepower. At low-water periods during the winter their aggregate capacity was undoubtedly less than 1,000 horsepower.

THE PORT WELLS GOLD-LODE DISTRICT.

By B. L. Johnson.

INTRODUCTION.

SCOPE OF REPORT.

The object of this report is to describe briefly the distribution, geologic relations, and characteristics of the gold deposits of the Port Wells district. Before the geology and mineral resources of the district are considered a concise description of the principal factors bearing on the economic development of the mineral deposits of the district will be given. This will be followed by a description of the geology, sufficiently complete to permit an understanding of the occurrence of the mineral deposits, the general discussion of which is followed by detailed descriptions of many of the ore deposits.

PREVIOUS WORK IN THE DISTRICT.

The earliest recorded exploration of the Port Wells district was made in June, 1794, by Whidbey, of Vancouver's[1] expedition. While Vancouver's ships lay in Port Chalmers, on Montague Island, a boat party in charge of Joseph Whidbey, in a yawl and a small cutter, examined and mapped the west shore of Prince William Sound from the southwest entrance to Bligh Island. Whidbey entered Port Wells, passing between Culross and Esther islands, visited Passage Canal and College Fiord, and left through Esther Passage. Ninety-three years later, in 1887, Capt. S. Applegate [2] in the schooner yacht *Nellie Juan*, explored and charted Port Wells. In 1898 an expedition under Capt. E. F. Glenn, of the United States Army, visited Port Wells. The reports of this expedition [3] contain much geographic information concerning this part of Alaska; that of W. C. Mendenhall,[4] who was attached to this expedition as geologist, furnished the first geologic information regarding the Port Wells

---

[1] Vancouver, George, Voyage of discovery to the North Pacific Ocean [etc.] in the years 1790-1795, 3 vols., maps, London, 1798; new ed., with corrections, 19 views and charts, 6 vols. (see vol. 5, pp. 269-320), 1801.

[2] Davidson, George, The glaciers of Alaska: Geog. Soc. Pacific Trans. and Proc., 2d ser., vol. 3, pp. 1-98, maps, 1904.

[3] Glenn, E. F., and Abercrombie, W. R., Reports of explorations in the Territory of Alaska (Cooks Inlet, Sushitna, Copper, and Tanana rivers), 1898, War Dept., Adjt. General's Office, No. 25, 1899.

[4] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898; U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 265-340, 1900.

district. In the following year (1899) the Harriman Alaska Expedition[1] spent several days in Port Wells, and the reports of the members of this expedition furnish much information regarding this district, especially on the glaciers and glaciation. In 1904 Davidson[2] compiled the existing data regarding the coastal glaciers of Alaska and described some of the Port Wells glaciers. Grant and Paige, in 1905, and Grant and Higgins, in 1908 and 1909, visited Port Wells on geologic reconnaissances for the United States Geological Survey. Certain of their reports[3] contain considerable data regarding the geography and geology of the Port Wells district. The National Geographic Society's expedition of 1910, under Lawrence Martin,[4] studied the glaciers and glaciation of College and Harriman fiords. Notes on the fluctuations of the glaciers of Port Wells have been published by Reid[5] from data obtained from Grant and Martin.

PRESENT INVESTIGATION.

The present investigation was undertaken as a result of numerous discoveries of gold-quartz deposits in the Port Wells district. Field work in this district was begun August 9, 1913, and brought to a close September 15, 1913. The use of the launch *Prospector*, of Cordova, Capt. George E. Scott, greatly facilitated the work. The base of the accompanying map (Pl. IX) was the reconnaissance map published as Plate II in Bulletin 443, United States Geological Survey, corrected by later surveys made by the United States Geological Survey and the United States Coast and Geodetic Survey, as shown on chart 8550.

For information furnished and assistance rendered during the course of the investigation the writer wishes to express his obligations to Messrs. George E. Scott, W. B. Harris, W. C. L. Beyers, Stephen Roe, Axel Frodenburg, W. L. Taylor, and many others.

---

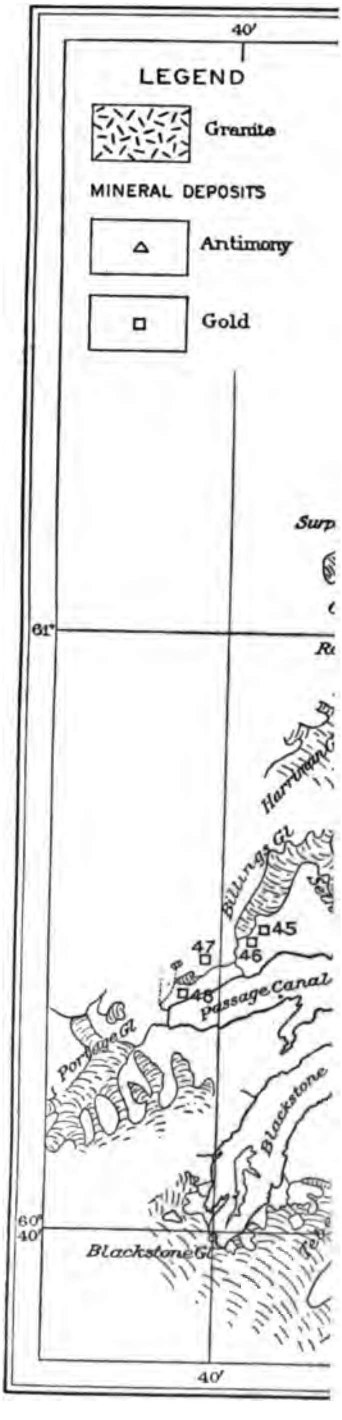
[1] Burroughs, John, Narrative of the expedition: Alaska, vol. 1, Harriman Alaska Expedition, pp. 1-118, 1901. Emerson, B. K., General geology; Notes on the stratigraphy and igneous rocks: Alaska, vol. 4, Harriman Alaska Expedition, pp. 11-56, 1904. Gannett, Henry, General geography: Idem, vol. 2, pp. 257-277, 1901. Gannett, Henry, Harriman Alaska Expedition: Nat. Geog. Mag., vol. 10, pp. 507-512, 1899; Am. Geog. Soc. Bull., vol. 31, pp. 344-355, 1899. Gilbert, G. K., Glaciers and glaciation: Alaska, vol. 3, Harriman Alaska Expedition, 231 pp., 27 pls., 11 figs., 1904. Muir, John, Notes on the Pacific coast glaciers: Idem, vol. 1, pp. 119-135, illus., 1902.

[2] Davidson, George, The glaciers of Alaska: Geog. Soc. Pacific Trans. and Proc., 2d ser., vol. 3, pp. 1-98, maps, 1904.

[3] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, 1910. Grant, U. S., and Higgins, D. F., (1) Glaciers of Prince William Sound and the southern part of the Kenai Peninsula, Alaska; (2) Glaciers of Port Wells, Prince William Sound: Am. Geog. Soc. Bull., vol. 43, pp. 321-338, 13 figs., 1911. Grant, U. S., and Higgins, D. F., Coastal glaciers of Prince William Sound and Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 526, 1913.

[4] Martin, Lawrence, The National Geographic Society's researches in Alaska: Nat. Geog. Mag., vol. 22, pp. 537-551, 553-560, 1911. Martin, Lawrence, Gletscheruntersuchungen längs der Küste von Alaska: Petermann's Mitt., Jahrg. 58, pp. 78-81, 3 pls., 1 map, 1912. Martin, Lawrence, Some features of glaciers and glaciation in College Fiord, Prince William Sound, Alaska: Zeitschr. für Gletscherkunde, Bd. 7, Heft 4, pp. 289-333, 1913. Martin, Lawrence, Alaskan glacier studies (in press).

[5] Reid, H. F., The variations of glaciers: Jour. Geology, vol. 17, pp. 667-671, 1909; vol. 19, pp. 454-461, 1911. Reid, H. F., Les variations périodiques des glaciers: XVIme rapport, 1910; Amérique du Nord: Zeitschr. für Gletscherkunde, Bd. 6, Heft 2, pp. 100-103, 1911.



Key to Mines and Prospects.

1. Cann & Minor.
2. Conley & McCheeney.
3. Sweepstake Mining Co.
4. Morning Star; North Star; Consolidated.
5. Nugget claim.
6. Mayflower claim.
7. Golden Wonder No. 9 claim.
8. Frodenburg & Bloom.
9. Mountain claim.
10. Lucky Swede claim.
11. Golden Wonder No. 1 claim.
12. Arrowhead (Johnson & Johnson) claim.
13. Edwin Griset.
14. Golden Eagle claim.
15. H. M. Carter.
16. Tolson & Stanton.
17. Paymaster (Peter Black) claim.
18. Hummel & Howell.
19. Walters, Brasslin & Atkinson.
20. Simonton & Mills.
21, 22. Charles Cameron.
23. Edwin Griset and O. T. Benson.
24. Mitchell & Myers.
25. Sheehan & Morgan.
26. Black & Hogan.
27. Reiter & Olson.
28. Sweepstake Mining Co.
29. White & Jones.
30. Michael Vincent.
31. Olsen & Viette.
32. A. P. Yannes.
33. Anderson & Yannes.
34. Joseph Harris.
35. Granite Gold Mining Co.
36. Reed, Gauthier & Cooper.
37. Yakima claim.
38. Hermann & Eaton.
39. George & McFarland.
40. Everson, Harris & Parker.
41. Westburg & Domenzet.
42. Dunklee & Reilly.
43. Kavanaugh & Boon.
44. Collins, Fish & Stewart.
45. Collins, Fish & Barry.
46. Bullion ledge.
47. Hillside claim.
48. Ernest King.
49. Gray Bros.
50. Stewart & Fish.
51. White & Pedersen.
52. Thomas-Culross Mining Co.
53. John Sells.

GEOGRAPHY.

LOCATION.

The Port Wells gold-quartz district lies in the northwest part of Prince William Sound and as here considered comprises the area adjacent to Port Wells and its tributary fiords. (See Pl. IX.) It includes Esther and Culross islands and the shores of the mainland bordering Esther and Culross passages and Eaglek Bay and also a small part of Kenai Peninsula lying farther southwest. As thus defined the district lies between parallels 60° 30′ and 61° 20′ north latitude and meridians 147° 40′ and 148° 50′ west longitude, and includes a total land, ice, and water area of about 750 square miles. The Port Wells district is within the Valdez recording district of the third judicial division of the Territory of Alaska. The recorder's office is at Valdez.

TOPOGRAPHY.

The Port Wells district lies within the Pacific Mountain province of Alaska and includes parts of the Chugach and Kenai mountains.[1] A low gap, occupied by the Portage Glacier, separates the Kenai and Chugach mountains.

The district has been intensely glaciated and includes two distinct types of glacial topography, one the result of high-level erosion, with sharp peaks, cirques, and comb ridges shaped by frost action above the surface of the glacier ice; the other the result of low-level erosion, with the rounded features of an area overridden and smoothed beneath glacial ice, which left rounded hills and spurs and U-shaped valleys.

The forms due to high-level erosion are found only in the higher mountains. High, sharp ranges border Port Wells and its tributary fiords on the west and north, and also occur in the northeast Kenai Mountains. The highest peaks are in the main range of the Chugach Mountains west and north of Port Wells. The maximum relief is found west of Harriman Fiord, where Mounts Gilbert and Muir rise to heights of 10,194[2] and 8,207[2] feet above sea level, respectively, within distances of 5¼ and 2 miles, respectively, from the fiord. Mount Gannett,[2] west of Barry Glacier, has an elevation of 9,240 feet. Higher peaks occur north of College Fiord, but the relief is less. The peaks on the outlying ridges of the main ranges, such as the ridge between College Fiord and Unakwik Inlet and the range between Passage Canal and Harriman Fiord, are from 4,000 to 8,000 feet high.

The rounded features produced by overriding glaciers are found on the lower slopes of the high, sharp ranges on Harriman and College fiords, Blackstone Bay, Passage Canal, Portage Passage, and on the borders and around the southern end of the sharp ridge between Col-

---

[1] Brooks, A. H., The geography and geology of Alaska: U. S. Geol. Survey Prof. Paper 45, pp. 16-17, 27-36, 1906.

[2] Martin, Lawrence, The National Geographic Society's researches in Alaska: Nat. Geog. Mag., vol. 22, p. 540, 1911; Alaskan glacier studies, p. 319 (in press).

lege Fiord and Unakwik Inlet. The foothills of these ranges on Point Pakenham, on the peninsula between Harriman Fiord and Port Wells, and between Cochrane Bay and Port Nellie Juan, also exhibit rounded features, and Esther and Culross islands are covered by rounded glaciated summits and slopes. Other characteristic low-level sculptured forms are everywhere seen within these areas. Practically all of this rounded topography lies below an elevation of 5,000 feet above sea level.

The shore line of the Port Wells district is very irregular, deeply indented, and fiorded like the rest of Prince William Sound. No part of the district is over 6 miles from tidewater.

The streams of the district are short, none being over 3 to 4 miles long. The principal streams are Coghill and Avery rivers. Coghill River is reported to drain a rather large lake. Members of the United States Geological Survey measured the discharge of some of the streams of the Port Wells district in 1913, and the results are presented elsewhere in this volume. The discharge of most of the streams varies greatly from season to season, the streams deriving a considerable part of their water from melting snow and glaciers. The steep gradients of some of the streams and numerous waterfalls offer possible sources of power for use in mining and other industries. A sawmill, driven by an overshot water wheel, was erected at the mouth of Avery River in 1913, and an arrastre near Golden was also driven by an overshot water wheel.

The present glaciers of the Port Wells district are principally of the alpine type. Rather extensive ice and snow fields, however, lie in the northern part of the peninsula between Harriman Fiord, Port Wells, and Passage Canal, in the mountainous country north of College Fiord, and in the area southwest of Blackstone Bay. Cap Glacier, south of the Crescent Glacier, between College Fiord and Unakwik Inlet, is reported to be a thin névé field, intermediate in character between the snow fields and the valley glaciers. The main centers of glaciation are in northeastern Kenai Peninsula and in the areas southwest, west, and north of Harriman Fiord and west and north of College Fiord. A few glaciers originate in the high parts of the peninsula between College Fiord and Unakwik Inlet. The most numerous glaciers of the Prince William Sound region are about the two northern arms of Port Wells—College and Harriman fiords. Most of these glaciers reach tidewater and are constantly discharging icebergs. Detailed descriptions of many of these glaciers have been published.

The submarine topography of the district does not differ greatly from that produced by the low-level sculpturing above sea level.[1] It appears to be chiefly the result of glacial erosion, as it shows little

---

[1] Martin, Lawrence, Some features of glaciers and glaciation in College Fiord, Prince William Sound, Alaska: Zeitschr. für Gletscherkunde, Bd. 7, Heft 5, pp. 32, 34-41, 1913. Martin, Lawrence, The National Geographic Society's researches in Alaska: Nat. Geog. Mag., vol. 22, 1911. Martin, Lawrence, Alaskan glacier studies (in press). U. S. Coast and Geodetic Survey cha [illegible]

deposition of sediments. Below sea level, the fiords, which were widened and deepened by glacial erosion, have the characteristic U-shaped cross sections, submarine hanging valleys, rock basins, confluence steps, and terminal moraines. These features are believed to have been caused by submarine glacial scouring. The depth of water along the axis of College Fiord ranges from 174 to 804 feet. In Harriman Fiord the maximum depth of water is 510 feet, in Pigot Bay 408 feet, in Barry Arm 588 feet, in Passage Canal 1,176 feet, in Blackstone Bay 1,188 feet, and in Port Wells, 1,518 feet. In the pocket between Culross, Esther, and Perry islands a sounding of 1,584 feet has been made. Typical submarine hanging valleys are the Yale Arm of College Fiord, which hangs 500 feet above the main fiord, Bettles Bay, and the cove of Serpentine Glacier, in Harriman Fiord. College Fiord and Barry Arm unite to form Port Wells, above which their mouths hang 350 to 400 feet. A submarine rock basin is shown by soundings in Pigot Bay. Submarine terminal moraines cross the mouths of Barry Arm and College Fiord.

CLIMATE.

No weather records have been kept within the area described in this report, but some are available for adjacent districts, at Seward, Sunrise, Valdez, and Cordova. The Port Wells district lies within the Pacific coast climatic province, the climate of which is essentially temperate and humid, being characterized by heavy precipitation and a comparatively high mean annual temperature.

The precipitation is about 132 inches at Cordova, 74 inches at Valdez, and 54 inches at Seward. In 1912 the total annual precipitation at Cordova was about 191 inches, but the rainfall in that year was exceptionally heavy in all parts of Prince William Sound. The records show further an average at different localities of 90 to 240 days in which some precipitation takes place. The total annual snowfall is 5 to 8 feet at Seward, 6 feet on Trail Creek, on the Alaska Northern Railroad, and 12 feet at Valdez.

The mean annual temperature of this province is 40° to 48° F. The lowest temperature recorded from this region is −14° F.; the highest is 82° F. The summers are cool, the average for the three summer months being about 51° F. The average temperature for the three winter months is 20° to 30° F.

Within the Port Wells district climatic conditions vary, but probably within the above limits. That lower temperatures prevail near the heads of the fiords than in other parts of the district is shown by the fact that the timber line descends to sea level at those points, whereas in the southeast part of the district, for example, in favorable situations, the conifers extend about 1,500 feet above sea level. Severe seaward-blowing winds are reported at the heads of the fiords in the winter.

TIMBER AND VEGETATION.

Only a small part of the total area of the district is forested, as is shown on the accompanying map (fig. 3), timber line being taken as the upper limit of coniferous trees. Timber line ranges from sea level at the upper ends of College and Harriman fiords, where the timber is small, grows in scattered groups, and is accompanied by little underbrush, to an elevation of about 1,500 feet in favorable situations in the southeastern part of the district, where heavy growths are found on the lower slopes. The forest trees are chiefly conifers, including spruce, western hemlock, and mountain hemlock. The native deciduous trees are cottonwood, willow, poplar, birch, and alder.

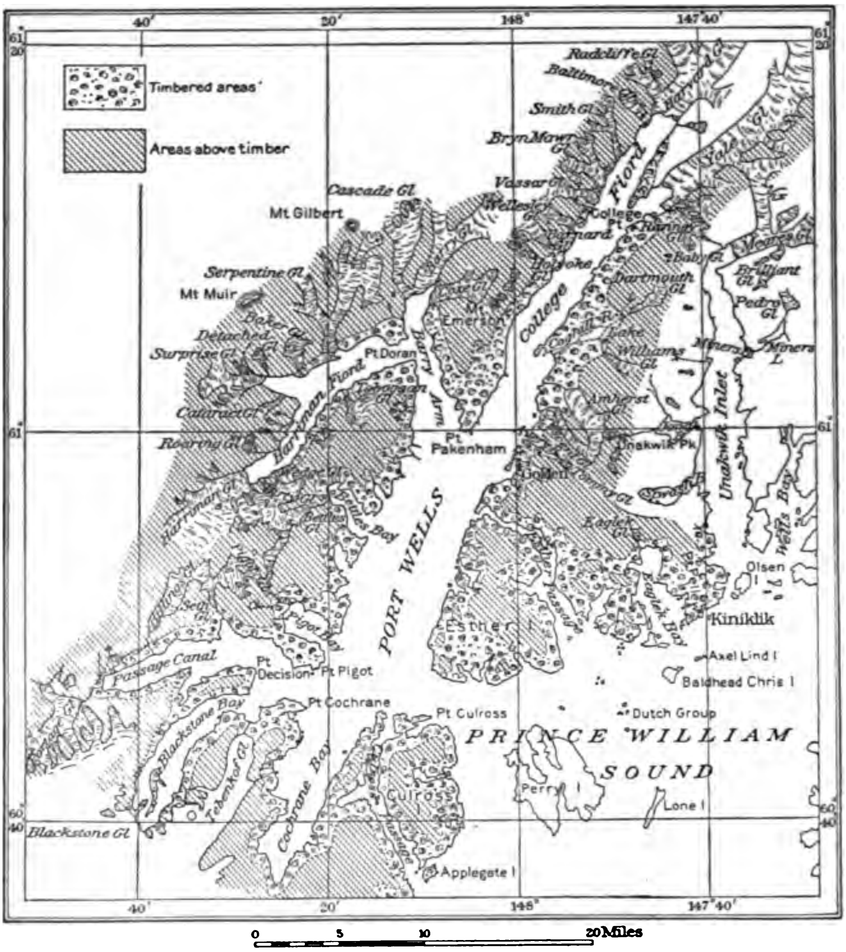


FIGURE 3.—Sketch map showing distribution of timber in the Port Wells district.

The Port Wells district is included within the Chugach National Forest, and the use of the timber is subject to the regulations of the

Forest Service, United States Department of Agriculture. The local office of the Forest Service is at Cordova. Commercial stands of timber are reported on Coghill River, Point Pakenham, Esther Passage, Harrison Lagoon, and Hummer Bay. Several booms have been cut in the Port Wells district for the Valdez sawmill. Only spruce trees are used. A few of the trees reach a diameter of 5 to 6 feet at the base, but these larger ones are usually branchy close to the base or are churn-butted, that is they taper abruptly. The size of butts in booms, measurements being made 16 feet above the cut, ranges from 17 to 36 inches, the average size being from 18 to 24 inches. Lumber suitable for most purposes can be cut near many of the prospects. The local needs for saw lumber are at present slight and will probably be largely met by a sawmill erected near the mouth of Avery River in 1913. Saw lumber is also obtainable at Valdez.

Devil's-clubs, salmonberries, blueberries, ferns, mosses, and flowers are abundant. Native grasses, suitable for horse feed, grow luxuriantly in some of the valleys and around timber line. All soils are glacially derived.

ANIMAL LIFE.

Mountain goats, a few black bears, and rarely brown bears are reported within the Port Wells district. Moose tracks have been observed by prospectors at the head of Port Nellie Juan on Kenai Peninsula, and possibly moose may occasionally stray into the Port Wells district. Keeler,[1] in 1899, noted Townsend's sparrow, the redpoll linnet, the Arctic tern, the short-billed gull, and the black oyster-catcher in Port Wells. Ptarmigan, tattlers, murrelets, ducks, and grouse have also been reported. Salmon, cod, trout, and other fish are caught in the waters of the district. Clams are found in a few places.

TRANSPORTATION.

The Port Wells district is reached by water. The main fiords and bays are navigable for large boats,[2] and at different times several of the large ocean-going steamers have entered these waters. Up to 1913 these visits have been irregular, however, no regular schedules or calling points having been maintained. In 1913 a 40-foot gasoline launch made weekly trips between Valdez and Golden, a distance of about 80 miles, carrying mail, passengers, and freight, stopping at Bettles and Hobo bays on each trip and making boat connections at Valdez for other Alaskan points and for Seattle. In 1913 there were no wharves or other means of landing in the Port Wells district and no hotels or roadhouses.

---

[1] Keeler, Charles, Days among Alaska birds: Alaska, vol. 2, Harriman Alaska Expedition, pp. 205-234, 1902.

[2] U. S. Coast and Geodetic Survey chart No. 8550.

Local transportation is largely by water, numerous small gasoline launches and rowboats being in use by prospectors for transporting supplies along the coast from the main distributing points. Though the conditions for water travel are especially favorable, land travel is difficult. The fiorded coast and mountainous back country will prevent any systematic development of land transportation within the district. A low pass between the head of Passage Canal and Turnagain Arm has been used by natives, Russians, and prospectors for many years for crossing from Cook Inlet waters to Prince William Sound. Trails have been built from many of the prospects to the nearest landing places on the shore, but they are usually steep and not well graded.

A fourth-class United States post office was established June 5, 1912, at Golden. The only local mail route maintained by the Post Office Department in 1913 was from Valdez by Unakwik Inlet (no office), Wells Bay (no office), and Hobo Bay (no office), to Golden and back twice a month from April 1 to October 31, and once a month from November 1 to March 31, each year. The contractor is required to perform the service by steamboat or other power boat.

POPULATION AND SETTLEMENTS.

Golden, on the east side of Port Wells, about 4 miles north of Esther Passage, was the only settlement in the district in 1913. It consists of a few cabins and tents scattered along the east shore of a small bay. The town is the main distributing point for the district, and supplies for prospecting are obtainable here at a slight advance over Valdez prices. There are no other permanent settlements in the district, but cabins have been erected on Avery River, Barry Arm, Thomas Bay on Culross Island, Bettles Bay, at Port Wells between Hobo Bay and Harrison Lagoon, and at Hobo Bay.

Gold quartz was first discovered in the vicinity of Golden in July, 1911, and in September, 1911, 21 tents were standing on the sand spit at Golden. About 150 men were prospecting around Golden in that year. In 1912 there were a few prospectors in the district, and 49 men are reported to have voted at the election in Golden in that year. About 20 people remained in Golden during the winter of 1912–13. In the early part of the summer of 1913 there were 75 to 100 men in the district, but later some of these left for the Chisana. There were only 12 men in Golden on September 8, 1913.

The population is chiefly white and is interested principally in prospecting for and developing gold-quartz properties. As in other mining districts of Alaska, the population is greatest in the summer.

GEOLOGY.

GENERAL FEATURES.

The Chugach and Kenai mountains, within which the Port Wells district lies, consist, so far as known, of closely folded sedimentary rocks, chiefly slates, argillites, and graywackes, and of minor amounts of greenstones and some large intrusive masses of granitic rocks. Mesozoic and Paleozoic sediments are probably included in the series, but neither the detailed structure nor the stratigraphic succession are known. Earlier workers in Prince William Sound have subdivided the rocks of that region into two great divisions, the Valdez and Orca groups. The Valdez group, presumably the older and more metamorphosed, is described as consisting principally of slates and graywackes; the Orca group comprises interbedded slates and graywackes, with extensive greenstone flows and agglomerates, as well as thick conglomerate beds. Granitic stocks are reported to intrude both Orca and Valdez rocks. The Valdez group has been assigned to the Paleozoic era by earlier writers, and the Orca has been considered of Mesozoic age.

After making a reconnaissance of the entire Prince William Sound region Grant and Higgins[1] have mapped the rocks of the Port Wells district as a part of the Valdez group. In 1913, however, fossils similar to those by which Grant and Higgins[2] assigned a probable Mesozoic age to the Orca group were found at several localities in the Port Wells district, and doubt was thereby cast on the assignment of at least a considerable part of the rocks of this district to the Valdez group.

SEDIMENTARY ROCKS.

SUBDIVISIONS.

The pre-Quaternary sedimentary rocks of this district are all regionally metamorphosed types, but some of them have been altered by local contact metamorphism produced by the intrusion of the large granite stocks. The variety of sedimentary rocks is not great. Four general lithologic subdivisions may be made: (1) Greenstones; (2) schists, slates, argillites, graywackes, and conglomerates; (3) contact-metamorphic rocks; and (4) conglomerates. The stratigraphic sequence of these subdivisions is probably the order in which they are mentioned, except the greenstones, whose position in the geologic column is not known.

---

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, Pl. II, 1910.

[2] Idem, pp. 32-33.

GREENSTONES OF CULROSS ISLAND.

A broad band of greenstone outcrops on the south shore of Thomas Bay, Culross Island, extending from the entrance to within half a mile of the head of the bay, a distance of about 2 miles. This greenstone band strikes about S. 30° W. and dips between 80° W. at the west contact and 75° E. at the east contact of the greenstone and adjoining slates. A narrower band of greenstone, outcropping on the east shore of Culross Passage about 3 miles from the southern entrance, has a slightly more southerly strike and a dip of 70° W.

These greenstones are greenish, much altered, basic igneous rocks, presumably lava flows. They range from light-green aphanitic, cherty-looking varieties to dark-green, very fine grained varieties. On Thomas Bay they are, as a whole, hard and massive but are sheared in many places. At the Culross Passage locality they are altered to light-green schists. Some of these schists were originally finely porphyritic rocks, with small feldspar phenocrysts.

SLATES, ARGILLITES, GRAYWACKES, AND CONGLOMERATES.

An interbedded series of slates, argillites, graywackes, and conglomerates covers the greater part of the Port Wells district. These rocks, so far as known, are of about the same age. Their relations to other formations are not known, and their subdivision into lithologic units must await detailed mapping. The total thickness of this series of rocks is not known, but must be many thousand feet. The eastern slopes of the mountains west of College and Harriman fiords, except Mount Emerson and its neighboring peaks, present in many places an apparent unbroken sequence of westward-dipping beds extending from sea level to their summits. Mount Muir, about 8,000 feet high, appears to consist chiefly of uniformly westward-dipping graywackes, including only here and there thin bands or lenses of slate. Near the summit of this mountain is a broad black band, probably slate, which is traceable for a great distance along the south and southeast faces of the mountain. On the west side of College Fiord and west of Barry Glacier individual graywacke members in a westward-dipping series, consisting chiefly of graywacke, are traceable for many thousand feet. North of Passage Canal cirques cut in northwestward-dipping sediments expose a section measuring 2,000 to 3,000 feet, consisting chiefly of graywacke but including four broad bands of slate which are traceable for fully a mile along the walls of the cirque. The section also includes zones consisting of narrow alternating bands of graywacke and slate. The rocks of the Point Pakenham group of peaks and the rest of the district are much more highly folded and faulted.

The general strike of the bedding and schistosity in the Port Wells district is from S. 30° W. to S. 70° W., conforming in general with the trend of the major topographic features of the district. The dips range from 60° W. to vertical, although a few easterly dips occur. The least deformed areas, as noted above, are in the high mountains in the west and northwest parts of the district.

Narrow alternations as well as more massive aggregates of each lithologic type occur within this series, and the individual beds range from narrow streaks to broad zones measuring many hundred feet across. Broad zones of thin-bedded slate and argillite alternate with broad bands of graywacke, and massive graywackes and argillites are seen, with only here and there a narrow band of slate. The contacts between slates and graywackes are abrupt and sharp, as are those between argillites and either slate or graywackes, but the conglomerates grade with no sharp breaks irregularly into the inclosing graywackes and show no planes of sedimentation.

Conglomerates are of widespread occurrence but are the least abundant of the members of the sequence. They are best developed on Harriman Fiord, College Fiord, and on the west side of Port Wells. Conglomerate bowlders are also found in the east lateral moraine of the Yale Glacier. Both pebbles and matrix of these conglomerate bowlders are cut by quartz veins. The conglomerate on Harriman Fiord also is cut by quartz veins, some of which are reported by prospectors to be well mineralized. The conglomerate on the north side of Harriman Glacier is at least several hundred feet thick and has been traced for fully a mile along the strike. Most of the conglomerate beds of the district have a thickness of only a few feet. The conglomerates are well lithified, joint cracks cutting across the pebbles. The matrix, which is light to dark gray in color, is predominantly a fine-grained graywacke; rarely it is argillaceous. The matrix usually forms but a comparatively small part of the rocks, the proportions increasing, however, with the gradation of the conglomerates into graywackes. The pebbles include slate, quartz, argillite, quartzite (?), chert, felsite, diabase, and altered andesitic rocks. Their color ranges from the white of the quartz through the light-green of altered igneous rock to the dark grays and black of the argillites and slates. No pebbles of granite similar to the granites of the Port Wells district were observed in these conglomerates. The pebbles in some of the conglomerate beds are chiefly thin angular slate fragments, few having diameters greater than 3 inches. In other beds the pebbles were chiefly of the harder rocks and these are usually well rounded and well assorted.

The graywackes are massive light to dark gray fine-grained sedimentary rocks. They are composed chiefly of subangular fragments of quartz and feldspar, together with fragments of other minerals and rocks, embedded in a fine-grained carbonaceous, calcareous, and argillaceous matrix. The coarser beds in many places contain flat angular fragments of slate. In some of the graywackes small fragm of fine-grained igneous rocks are numerous, and in one specimen the presence of grains of hornblende and pyroxene and fragments of graywacke, a fine-grained carbonaceous sedimentary rock, and a basaltic rock with feldspar laths, were observed. Some of these more basic graywackes are associated with the conglomerate on Harriman Fiord, which contains numerous igneous pebbles, and both were probably derived to a large extent from the erosion of basic igneous rocks.

The argillites are dark-colored, dense, very fine-grained, structureless sedimentary rocks. Most of the fossils which have thus far been collected in them have been found on the bedding planes of thin-bedded black argillites. The slates are dark-gray to black rocks with well-developed slaty cleavage. These rocks present all gradations in color and fineness of grain, from slates through argillites and graywackes to conglomerates.

Folding and shearing subsequent to the deposition of the beds of this series has rendered these rocks schistose in many places. Mica schists were also produced on Esther and Culross islands by the contact metamorphism accompanying the granite intrusions.

CONTACT-METAMORPHIC ROCKS.[1]

The larger granitic stocks of the Port Wells district are surrounded by aureoles of contact-metamorphic rocks produced by the intrusion of the granite masses into the sedimentary rocks. The metamorphism of the graywackes and slates has yielded altered graywackes, mica schists, and knotted sillimanite schists. Within these contact-metamorphosed zones on both Esther and Culross islands are areas of gabbroic rocks whose exact genetic relations are uncertain. The gabbros of Esther Island have been considered pregranitic intrusives,[2] but their field relations suggest that they may be recrystallized basic igneous rocks. All these contact rocks are intruded by granite and granitic, aplitic, and pegmatitic offshoots of the granite stocks.

The altered graywackes are fine-grained, light reddish-brown rocks, composed of quartz and biotite with a few grains of orthoclase and plagioclase. The biotite is sufficiently abundant to give a characteristic reddish-brown color to the rocks. Nearer the contacts the rocks are medium grained, dark gray, massive, and more crystalline. Biotite mica schists and dioritic-looking rocks are the prevailing types. Biotite is still the predominant ferromagnesian constituent. Hornblende, muscovite, epidote, and apatite also occur. Knotted dark-gray slaty schists are found also on Esther and Culross islands.

---

[1] See also Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, pp. 20, 37, 38, 40-41, 49, 1910.

[2] Idem, p. 49.

The gabbros are fine to coarse grained dark-gray to greenish rocks. Grant and Higgins's description[1] of the gabbro on the east side of Esther Island is as follows:

> This gabbro exists in several phases. One phase is made up largely of poikilitic crystals of augite inclosing prismoid crystals of labradorite. This feldspar is about the same in all the phases of the gabbro. It is beautifully twinned, according to both the albite and pericline laws. Another phase has in addition to the augite and labradorite a considerable quantity of olivine which is very fresh. About each grain of olivine is a zone made up of thousands of acicular colorless crystals of actinolite. * * * No mechanical effects of deformation, such as granulation or slicing, are present in the gabbro.

On Culross Passage is found "a somewhat altered gabbro rather high in plagioclase feldspar (labradorite) and with a partial ophitic texture."[2] These basic rocks are in some places slightly mineralized by chalcopyrite and pyrrhotite.

CONGLOMERATE.

A conglomerate-filled joint crack occurs on the south side of Point Cochrane and similar occurrences are reported on Point Pigot. On Point Cochrane the conglomerate cuts squarely across an interbedded series of black slates, dark-banded argillites, and massive graywackes striking S. 30° W. and dipping 65° W. to 90°. Abundant worm tubes (*Terebellina palachei* Ulrich) were found in this slate-graywacke series, and an argillite bowlder on the shore yielded an Inoceramya. This conglomerate, occupying a joint crack that strikes N. 75° W. and dips 85° N. to vertical, is traceable 100 feet across the beach. The width of the conglomerate band ranges from 6 inches (at the water's edge) to 2 feet. The conglomerate band is narrowest at the east end, where the pebbles are smaller and the rock is darker colored. The walls are sharp, distinct, and smooth. At one point a narrow conglomerate stringer extends out into the south wall along a crack in the graywacke. This stringer narrows down to one-fourth inch before it ends 6 feet from where it left the main conglomerate and 2 feet south of it.

The conglomerate is a well-lithified dark-gray rock, darker than the older conglomerates of the district. The matrix is very fine grained. The pebbles range from some the size of pin points to well-rounded bowlders measuring 10 by 21 inches. They include graywacke, argillite, slate, quartz, and a very few small light-gray, very fine grained pebbles, possibly of an igneous rock similar to a dike which outcrops near by. A characteristic feature of this conglomerate is the numerous rounded pebbles and bowlders of light reddish-brown metamorphosed biotitic graywacke similar to the rock occurring in the contact zones of the granites of Culross and Esther islands.

---

[1] Grant, U. S., and Higgins, D. F., op. cit., p. 49.

[2] Idem, p. 37.

GREENSTONE TUFF.

Numerous bowlders of greenstone tuff are found in the beach gravels (wash) of Port Wells. They are dense fine-grained rocks of light-green color, conspicuous on account of the numerous small, thin, angular fragments of black slate which they contain. No rock similar to this has been found in place in this district, but some may occur in the higher parts of the mountains around Barry Glacier and the head of College Fiord. Paige and Knopf[1] have described similar rocks in the valley of Knik River.

AGE AND CORRELATION.

The age of the sedimentary rocks of the Port Wells district is not definitely known, but in the light of present knowledge they appear to be in part Mesozoic and in part Paleozoic. Collections of fossils were made in 1913 in the slate-graywacke series at several points, but the paleontologic evidence was insufficient for an assignment of this series to a definite position in the geologic column. T. W. Stanton reported on the invertebrates collected as follows:

> The invertebrates of this collection are all referable to species of somewhat obscure nature, described by Mr. Ulrich as coming from the Yakutat group of Alaska, but I do not consider this determination to be established, although no additional information has come to light since it was published.

The fossils identified by Mr. Stanton were the following:

Collection of invertebrate fossils from the Port Wells district, Alaska.

13 AJ 128 (8601). North side of Barry Arm, about a mile south of Coxe Glacier.
 Inoceramya concentrica Ulrich.
13 AJ 217 (8602). Point Cochrane.
 Terebellina palachei Ulrich.
 Trails, etc.
13 AJ 218 (8603). Fossil float from Point Cochrane.
 Inoceramya concentrica Ulrich.
 Terebellina palachei Ulrich.
13 AJ 260 (8604). East side of Coghill Point, College Fiord.
 Terebellina palachei Ulrich.

Worm trails were also found at many other places in the district, and *Inoceramya concentrica* Ulrich was also seen in place in the slate-graywacke series on the west shore of Barry Arm at its junction with the north shore of Harriman Fiord. No collection was made at this place.

Certain other organisms collected in Port Wells in 1913 were determined by F. H. Knowlton, as follows:

---

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the [illegible] Alaska: U. S. Geol. Survey Bull. 327, pp. 13-16, 1907.

Collection of fossil plants from Port Wells, Alaska.

13 AJ 113 (6710). East side of College Fiord at Minor's prospect.
  Helminthoida abnormis Ulrich.
  Helminthoida vaga Ulrich.
13 AJ 128 (6711). North side of Barry Arm, about 1 mile south of Coxe Glacier.
  Helminthoida abnormis Ulrich.
13 AJ 216 (6712). Cochrane Bay, west side, near head of bay.
  Calcellophycus rhombicum Ulrich.

Mr. Knowlton's comment on these fossils follows:

> These peculiar organisms are identified without hesitation as being the same forms named and described by E. O. Ulrich (Alaska, vol. 4, Harriman Alaska Expedition), from the Yakutat group, mainly near Kodiak, Alaska. Ulrich regards the age as Lower Jurassic, and to this I have nothing to add.

The slate, graywacke, and conglomerate series of Port Wells, therefore, from the evidence afforded by fossils, appears to be synchronous with the slates and graywackes on Woody Island near Kodiak and to be possibly of early Mesozoic age. It will be remembered that a Mesozoic age was assigned to the Orca group also, largely on account of the presence of the worm tubes *Terebellina palachei* Ulrich in the slates of that group.[1] The exact position of these terranes in the geologic column, however, is still in doubt.

The age of the greenstone on Culross Island is not known, but it is probably to be correlated with the greenstones of the Orca group of the rest of Prince William Sound.

The conglomerate at Point Cochrane was deposited in a fissure in the slate-graywacke series after the intrusion of the Esther granite and the granite of Culross Island, and the contemporaneous metamorphism of the intruded sediments. It is probably of late Mesozoic or Tertiary age.

INTRUSIVE IGNEOUS ROCKS.

DEEP-SEATED INTRUSIVES.

The deep-seated intrusive rocks of Port Wells are granitic bosses intrusive into much contorted sedimentary rocks of the slate-graywacke series. Large granite bosses form the central parts of Esther and Culross islands. Another large stock is exposed on Passage Canal, and several smaller irregular intrusions occur on the peninsula between Harriman Fiord and Port Wells and on the north side of Harriman Fiord and Barry Arm. The intrusive character of these granites is well established by the lack of basal conglomerates about the granites, by the contact metamorphism of the sediments about the stocks, and by the presence of dikes extending from the

---

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, p. 33, 1910.

granite into the surrounding sediments. With the exception of certain dike rocks and the conglomerate filling of the fissure on Point Cochrane, these granite intrusives are probably the youngest pre-Quaternary rocks of the Port Wells district.

Several of these granite intrusives have been described in detail by Grant and Higgins,[1] and much of the following description of the granites of Esther and Culross islands and the Passage Canal is abstracted from their report. The granite on Culross Island is a rather dark gray biotite granite. The quartz shows marked undulatory extinction and contains numerous roughly parallel sheets and lines of inclusions. The plagioclase varies from nearly pure albite in some individuals to oligoclase-albite in others. Both plagioclase and orthoclase are somewhat altered to sericite. The biotite is altering to actinolite. Magnetite, apatite, zircon, and sphene are also reported. Small brown grains, possibly allanite, are associated with the biotite. The aplitic phases of the granite are finer grained than the main granite. Their lighter color is due to a decrease in the quantity of biotite present.

A gray fine-grained granite covers an area about 4 miles long and 2 miles wide on the north side of Passage Canal. The feldspar content of this rock is chiefly orthoclase, but includes a few crystals of plagioclase, varying between andesine and oligoclase. The only dark mineral present is biotite, in part altered to chlorite. Small amounts of apatite, magnetite, and zircon are reported. A vug in this granite contained crystals of quartz, albite ($Ab_{93}An_7$), and chlorite.

The Esther granite, a gneissic biotite-hornblende granite, is the largest intrusive mass in the Port Wells district and one of the largest of the Prince William Sound region. It forms the greater part of Esther Island and covers an area approximately 4½ miles wide by 9 miles long. This granite is in most places slightly porphyritic with orthoclase phenocrysts. Smaller crystals of orthoclase occur in the groundmass. The plagioclase is about $Ab_{65}An_{35}$, or oligoclase-andesine, but many of the crystals have more acidic rims that grade to about albite-oligoclase in composition. The quartz is very undulatory and segmental in its extinction and in some places is partly granulated. Biotite is present in considerable amounts in all phases of the granite. The amount of hornblende varies from scarcely any to as much as the biotite. Accessory minerals are magnetite, apatite, zircon, and sphene. The average chemical and mineral composition of this granite, as determined by Grant and Higgins [2] by the Rosiwal method, is as follows:

---

[1] Grant, U. S., and Higgins, D. F., op. cit., pp. 30-46, 1910.

[2] Idem, p. [illegible], 1910.

Average mineral composition of the Esther granite.

Quartz	30.7
Orthoclase	19.2
Plagioclase ($Ab_{65}An_{35}$)	25.8
Biotite	17.1
Hornblende	7.1
Magnetite	.1

Average chemical composition of the Esther granite.

SiO_2	66.7
Al_2O_3	13.6
Fe_2O_3	1.4
FeO	3.0
MgO	2.9
CaO	3.6
Na_2O	1.6
K_2O	4.9
H_2O	.8
MnO	.1
	98.6

A small exposure of granite on the north side of Barry Arm consists of a medium-grained, light grayish-green, much altered granitoid rock, composed principally of quartz, orthoclase, plagioclase, and calcite. Sericitization of the feldspars is marked. The ferromagnesian minerals are altered to a light-greenish aggregate. The contact phase of this granite is a light gray rock with an aphanitic groundmass and scattered greenish rodlike phenocrysts, possibly originally amphiboles.

A granite outcropping on the property of the Granite Gold Mining Co., on the west side of Port Wells, is a medium-grained, equigranular light greenish-gray rock, composed of quartz, feldspars, biotite, sericite, and chlorite. The ferromagnesian minerals are almost completely altered. The granite is cut by small quartz veins bordered by narrow carbonate bands which weather brown. Larger well-mineralized quartz veins occur in close association with this granite.

On the tip of a small point on the west shore of Port Wells between the above property and Harrison Lagoon, a breccia of slate, graywacke, and granite has been further brecciated and intruded by a similar granite, which in some places acts as a cement to both igneous and sedimentary material. In other places the breccia is cemented by an irregular network of porous crystalline quartz. Pyrite cubes, the largest half an inch across, occur in the granite. Graywacke and black banded argillite blocks up to 10 feet square are found in the breccia.

The gabbros in the contact zones of these intrusives are described under the heading "Contact-metamorphic rocks" (p. 206).

DIKE ROCKS.

Numerous light-colored dikes cut the slates and graywackes of the Port Wells district and contrast strongly with the dark sedimentary rocks. The contact zones of metamorphosed sedimentary rocks surrounding the large granitic stocks on Esther and Culross islands are intruded by pegmatite and aplite dikes, and a few aplite offshoots from the granite of the Passage Canal extend into the sedimentary rocks on the north shore of Passage Canal. Large, nearly vertical dikes can be seen in the hills at the head of Pigot Bay, cutting the sediments back of and over the granite of Passage Canal; they are probably offshoots from this stock. Other dikes, provisionally termed quartz diorite porphyries, are widely distributed in the sedimentary rocks at long distances from the known granite areas. This occurrence, noted also in the Sitka district[1] and in the Seward-Sunrise region,[2] is equally marked in Port Wells.

Pegmatite, aplite, and granite dikes are abundant in the recrystallized rocks that surround the larger granite masses, and a few fine-grained sugary aplite dikes cut the granites on Esther Island and Barry Arm. Short, narrow dikes of aplite with quartz centers cut the Esther granite, and the metamorphosed sediments that surround this granite are intricately intruded by a variety of dikes, which show all gradations between white sugary garnetiferous soda aplites, composed chiefly of albite, orthoclase, and quartz; light blue-gray aplites with variable amounts of garnets and biotite; coarse-grained bluish-gray pegmatites; and fine-grained biotite granites. The metamorphic rocks on the south side of the granite of Culross Island are cut by numerous granitic and acidic dikes, most of them small. Some of the aplite dikes of the district are slightly mineralized. A small amount of pyrrhotite and chalcopyrite was observed along the center of one of the blue-gray aplite dikes on Esther Island, and in aplite dikes cutting the granite of Barry Arm pyrite, chalcopyrite, and arsenopyrite were recognized.

Dikes that may provisionally be termed quartz diorite porphyries occur in most parts of the district, but none are known in the vicinity of Golden or Avery River or on Esther or Culross islands. Most of these dikes are only 4 to 6 feet wide, although much larger ones are seen in a few places. They are aphanitic to obscurely finely porphyritic, with abundant rodlike phenocrysts. Extensive alteration has in many places obliterated the original porphyritic texture. These dike rocks are generally light greenish white to greenish gray, the phenocrysts being slightly darker than the groundmass. The rocks are usually much altered; the ferromagnesian minerals are com-

---

[1] Knopf, Adolph, The Sitka mining district, Alaska: U. S. Geol. Survey Bull. 504, p. 17, 1912.

[2] Johnson, B. L., Gold deposits of the Seward-Sunrise region, Kenai Peninsula: U. S. Geol. Survey Bull. 520, p. 140, 1912.

pletely changed and the sericitization of the feldspars is well advanced. The chief constituents of the altered rocks are quartz, feldspar (principally plagioclase), calcite, sericite, and chlorite. Plagioclase occurs both as phenocrysts and in the groundmass. The original ferromagnesian phenocrysts are now completely altered to aggregates of calcite, sericite, chlorite, and epidote, so that their original character is unknown, but some specimens are reported[1] to show distinctive amphibole cross sections. Some of the altered dikes contain mineralized veinlets of quartz and calcite, and dikes with such veinlets are usually metallized. Arsenopyrite and pyrite are the usual secondary sulphides in these metallized dikes.

QUATERNARY DEPOSITS.

The Quaternary sediments consist of unconsolidated material, resting unconformably on the glaciated surfaces of igneous and metamorphic rocks and include glacial deposits of various types, terrace gravels, outwash gravels, delta deposits, beach deposits, and stream gravels. Much of the material is of glacial origin, although most of it has been later reworked by stream or wave action.

Purely glacial deposits are not abundant. A ground moraine, thin and patchy, covers the lower overridden bedrock slopes. Terminal morainal dams exist in the valley of Coghill River. Crescentic terminal moraines remain in front of Baker, Roaring, Bryn Mawr, and Wellesley glaciers, and fragments of early terminal moraines are found in front of Serpentine, Barry, Yale, Harvard, and Blackstone glaciers. An ablation moraine covers the lower lobate portion of Vassar Glacier. Submarine terminal moraines, or moraine bars, cross the mouths of Barry Arm and College Fiord, and the terminal moraine built by the Barry Glacier about 1898 extends below sea level. Medial moraines can be seen on some of the existing glaciers, such as the Bryn Mawr and Harvard glaciers. Lateral moraines are also well developed on and near some of the present glaciers.

Gravel terraces rest on the walls of College Fiord, and several of the cascading glaciers of College Fiord have built terminal moraines and outwash fans into the fiord, giving rise to a narrow flat at the base of the western fiord wall. Small alluvial and delta fans have also been built by streams from hanging glaciers into many of the fiords. Sand and gravel beaches, small and narrow, stretch along the shores or lie in rocky coves. Sandy bars, or spits, nearly close the mouths of lagoons at Golden, Point Pakenham, Hobo, and other bays. The outwash gravel plain near Amherst, Crescent, Williams, and Dartmouth glaciers is the largest deposit of this type in College Fiord. Other large outwash plains lie in front of the Toboggan, Serpentine,

---

[1] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, p. 47, 1910.

Baker, Dirty, Pigot, Bettles, Portage, and Tebenkof glaciers, and on the west side of the terminal moraine built by the Barry Glacier about 1898. Tidal flats occur at the heads of many of the bays.

MINERAL RESOURCES.

DEPOSITS EXPLOITED.

The mineral resources of the Port Wells district comprise deposits of gold, silver, and antimony. At present gold and silver are the only metals recovered from the ores of this district. The gold produced comes only from lode deposits, and the silver occurs alloyed with the native gold of the gold ores. There are no productive gold-bearing gravels in the district, although colors of gold are reported in the outwash gravels at the head of Blackstone Bay and on Passage Canal. The deposits of antimony are small and of little commercial importance. An antimony prospect on Barry Arm has been described by Grant[1] in an earlier report. Only a few small stibnite-bearing quartz veins have since been found.

HISTORY.

Prospecting has been in progress in the Port Wells district since at least 1896. In that year Teening Carlson and Albert Nordstrom are reported to have discovered gold-bearing gravels on the Billings Glacier stream, on Passage Canal. Mendenhall[2] noted the presence of pyrite-bearing quartz veins on Passage Canal in 1898, but no gold-quartz prospects are known to have been located in this district until 1907, when Albert Nordstrom, Teening Carlson, Ludwig Christiansen, and two others are said to have discovered and located the vein on what is now the property of the Thomas-Culross Mining Co., on Culross Island. This property was not held by the discoverers, and in October, 1910, the ground was relocated by N. L. Thomas, M. G. Thomas, and Ludwig Christiansen. The discovery, in the year 1911, on the south side of the lagoon at Golden, of a large bowlder of gold-bearing quartz, estimated to weigh 1½ tons, marks the beginning of a new period of mining activity in the Port Wells district. On July 31, 1911, the Golden Wonder No. 1 and Golden Wonder No. 9 veins were located by Charles Anderson and Louis Little. Following this discovery of gold-quartz veins at Golden a small rush of prospectors to the district took place, and much prospecting and locating of veins in that vicinity occurred. Most of the properties around Avery River and Golden were located in 1911.

---

[1] Grant, U. S., and Higgins, D. F., op. cit., p. 78.

[2] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, p. 306, 1900.

During the winter of 1911–12 development work is reported to have been in progress at several of these properties and at one on the west side of Esther Island. The season of 1912 was wet and unfavorable to prospecting, but some veins were discovered, chiefly on the west side of Port Wells. Development work continued on several properties during that year and the following winter. In 1913 numerous prospectors were scattered over the district and several new veins were discovered. Development work was in progress on properties at Golden, Avery River, Culross Island, Port Wells, Harriman Fiord, and Barry Arm. A few small test shipments of gold quartz were made to Valdez and Tacoma in 1911 and the following years. In 1913 an arrastre was erected at the Tolson & Stanton property at Golden. In the winter of 1913–14 a Lane mill is reported to have been installed at the property of the Granite Gold Mining Co., on the west side of Port Wells.

GEOGRAPHIC DISTRIBUTION OF THE ORE DEPOSITS.

The Port Wells district is one of several more or less isolated gold-quartz districts which lie in a broad belt, concave southward, bordering Prince William Sound from McKinley Lake to Seward. The general characteristics of these districts are much alike and the deposits of the Port Wells district differ little from the gold-quartz deposits of the near-by Valdez and Seward-Sunrise districts.

The known mineralized portion of the Port Wells district has a northeast-southwest trend, paralleling in general the strike of College Fiord, Port Wells, and Cochrane Bay. (See Pl. IX.) The mineralized area, which is a few miles wide at the north end of College Fiord, widens rapidly southwestward and at the south end of the district has a width between known gold prospects of about 30 miles and extends in an east-west direction from Portage Glacier Pass to Eaglek Bay. The mineralized area apparently continues southwestward into Kenai Peninsula. Most of the prospects have been discovered in the west-central part of this triangular area, about Golden and Point Pakenham, and on the peninsula between Harriman Fiord, Port Wells, and Passage Canal.

The known vertical range of mineralization is over 3,000 feet, extending from sea level in various parts of the district to an elevation of more than 3,000 feet at the Hummel-Howell prospect, on the east side of Barry Arm. Gold deposits are distributed throughout the entire vertical range of mineralization, but very few have yet been discovered over 2,000 feet above sea level.

Prior to September 1, 1913, the gold and silver produced in the Port Wells district had been only that recovered from small sample lots of gold-quartz ore shipped from the several properties in the district to Valdez and the Tacoma smelter and its value probably did not exceed $3,000. An arrastre near Golden was nearly completed during the summer of 1913 but was not in operation on September 1. Early in 1914, after the erection of a Lane mill, the Granite Gold Mining Co., on Port Wells, began to produce gold.

GEOLOGIC RELATIONS OF THE ORE DEPOSITS.

STRUCTURAL RELATIONS.

The determination of the distribution of the gold-quartz veins of the Port Wells district is largely a structural problem. The lodes appear to be most abundant in the more disturbed rocks, which are included in the triangular area between Mount Emerson, College Fiord, and Barry Arm, the peninsula between Harriman Fiord, Port Wells, and Passage Canal, and the region adjacent to Avery River and Golden. Three periods of fissuring are indicated. The first set of fissures resulted from the deformation contemporaneous with the intrusion of the granites and dikes; the second set of fissures, which were filled by quartz veins, were formed after the igneous intrusions; the third set were formed by post-mineral movements. Some of the earlier fissures appear to have been places of earth movements throughout all three epochs.

The gold deposits of the district are principally veins but include a few stringer lodes, and some of the acidic dikes have been shattered and cemented by mineralized quartz. The strikes of the veins vary locally. Northeast strikes prevail around Golden, for instance, and northwest strikes are most prominent on Barry Arm, Bettles Bay, and at some places on the west side of Port Wells. Taking the district as a whole, however, the strikes lie within the 145° included between N. 55° W. and east-west. The dips are as a rule between 60° and 90°. The veins and fissures are narrow, their width ranging generally from a few inches to 3 or 4 feet. Some of the fissures are sharp, clean cut, and quartz filled; others are shattered zones, lenses, or irregular networks of quartz cementing fractures between well-defined walls; and in still others the filling is chiefly pulverized and shattered country rock with but little quartz.

The character of the country rock has had little, if any, chemical effect on the deposition of most of the gold-bearing ores of this district. Most of the lodes are in the slate, argillite, graywacke, and conglomerate members of the slate-graywacke series. They show no evidence of chemical action in effecting ore deposition, and have the appearance of simple fissure fillings. In the greenstone of Culross Island and in the mineralized acidic dikes of the district a slight amount of sulphide impregnation of the altered country rock of the veins has taken place.

AGE OF MINERALIZATION.

The gold ores of the Port Wells district were formed after the deformation of the slate, graywacke, and conglomerate series and the intrusion of the granites and the quartz diorite porphyry dikes. The granite of Barry Arm is cut by sulphide-bearing aplite dikes and was itself slightly mineralized after its intrusion and solidification. The granite on the property of the Granite Gold Mining Co. on Port Wells is cut by gold-bearing quartz veins. Sulphide-bearing pegmatites occur on Esther Island. Whether the sulphides are original constituents of these aplite and pegmatite dike rocks is not now known. Several of the quartz diorite porphyry dikes of the district have been shattered and then mineralized. An intimate relation is indicated between the igneous intrusions of the district and the metalliferous deposits. It appears closest between the aplite and pegmatite dikes and the quartz veins. No actual gradation from aplite or pegmatite dikes to quartz veins has been observed, however, although certain of the aplite dikes have quartz centers and in some places carry sulphides.

The mineralization of the Port Wells district is probably of Mesozoic age, following closely the granitic intrusions. It probably preceded the formation of the conglomerate on Point Cochrane, bowlders of contact-metamorphosed rocks similar to those produced by the granitic intrusions occurring in this conglomerate.

CHARACTER OF THE ORES.

The ores of the Port Wells district are free-milling gold-quartz ores. The ore minerals are primary, the intense glacial scouring to which this district has been subjected removing any preglacial enriched zones which may once have existed and exposing the original sulphide ore deposits at the surface. The recentness of this glaciation has, moreover, afforded little opportunity for later surface alteration of the deposits. A small portion of the sulphides in the outcrops has been oxidized, but primary unaltered sulphides also show in practically all outcrops.

The mineralogy of the ores is simple. The dominant nonmetallic gangue mineral is quartz. Minor amounts of calcite and chlorite also occur. Mendenhall[1] has recorded the presence of fluorite in quartz veins on Passage Canal, but none was observed in the specimens collected in 1913. The primary metallic minerals of the ores are gold, silver, pyrite, galena, sphalerite, pyrrhotite, arsenopyrite, stibnite, and chalcopyrite. The economically important minerals are gold and silver, the silver occurring alloyed with the native gold.

---

[1] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, p. 300, 1900.

Secondary minerals found in the weathered outcrops of the veins are of little importance. Limonite is the most common oxidation product. The relative abundance of the gangue and metallic ore minerals is not known, but the sulphides are not particularly abundant in most of the ores.

GOLD-QUARTZ PROSPECTS.

ORDER OF DESCRIPTION.

The following descriptions are based on short visits to the properties examined, supplemented by office examination of the specimens collected at each property. All the prospects in the district were not visited, but enough were seen to permit general conclusions to be formed regarding the occurrence of the ore bodies. The descriptions are grouped by separate fiords and bays so far as possible, and these fiords are considered in geographic order from north to south. The arrangement of localities in each fiord has no significance as to relative importance of the separate prospects, nor is the amount of space devoted to a prospect any measure of its economic value.

COLLEGE FIORD.

General conditions.—Good gold-quartz float has been reported on the upper end of College Fiord and considerable staking has been done, but the Minor prospect is the only one on which any underground development work has been done. Some gold-quartz float is also said to have been found near Williams Glacier, and an arsenopyrite ledge is reported in the mountains at the head of Coghill River. The Point Pakenham prospects are described together under the heading Barry Arm, and the Avery River and Golden prospects are considered under separate headings.

Cann & Minor prospect.—The prospect of J. H. Cann and C. J. Minor is on the east side of College Fiord, about 2 miles north of the mouth of Coghill River. The development work consists of a tunnel near sea level, about 65 feet long, and some stripping along the ledge above the tunnel and on a vein at an elevation of 250 feet. The country rock at the tunnel is slate and massive graywacke cut by an acidic dike. The vein is closely associated with the dike, in places cementing the shattered dike rock. The tunnel is driven S. 9° W. along a fault that intersects both dike and vein. The quartz exposed ranges in width from a few inches to 6 feet. The dike has a maximum observed width of 5 feet. Some calcite-bearing quartz stringers cut the graywacke at the mouth of the tunnel. The country rock at the upper showing is graywacke. The vein is about 3 feet wide and is exposed for 20 feet. It strikes approximately N. 56° W. and has a vertical dip. The walls are free but show no gouge. The mineralization appears to be slight in both veins. Quartz, calcite, pyrite, sphalerite, and chalcopyrite were recognized in the ores.

AVERY RIVER.

Conley & McChesney prospects.—These prospects were not visited, and the information regarding them given below was obtained from W. M. Conley. The Bluebell, Perseverance, and Whistler claims are said to be on the north side of Avery River between 2 and 3 miles from its mouth. The development work consists of a 40-foot tunnel on the Bluebell claim, a 10-foot shaft on the Whistler, and some stripping. The first two claims are reported to have been located in September, 1911, by W. M. Conley and R. J. McChesney. The vein on the Bluebell is 18 inches to 8 feet wide, that on the Whistler 3 feet wide, and that on the Perseverance several feet. All three veins are said to be traceable for considerable distances. Ore specimens from the Perseverance shown to the writer were bluish quartz with few sulphides. In specimens from the Whistler claim the quartz carried galena, pyrite, and chalcopyrite.

Prospect of Sweepstake Mining Co.—The Avery River prospect of the Sweepstake Mining Co. is on the north side of Avery River, above timber line, about 2 miles from the mouth of the river. The developments by the company include a 100-foot tunnel, an 18-foot shaft filled with water at time of the writer's visit, a trail from the mouth of the river to the workings, a log cabin, and a sawmill at the mouth of Avery River. The veins were discovered in November, 1911, by Charles Elwood and John Reuef. Development work is reported to have been started about March, 1912. Several tons of good ore taken from the shaft are said to have been shipped to Valdez in the spring of 1912.

The shaft, which is at an elevation of about 1,880 feet, was sunk on a fissure 5 feet wide, the ore shoot in which had a maximum width of 16 to 18 inches and a length as stripped of about 20 feet. The fissure strikes N. 65° W. and dips 45° W. in a thin-cleaved slate country. At the east end of the workings the fissure was 5 feet wide, but only the 4 inches of the fissure filling next the hanging wall carried quartz veins. The rest of the fissure filling consisted of black slate with a few small cross-cutting quartz stringers. The tunnel was driven at an elevation of 1,850 feet to intersect this fissure. The rock in the tunnel consists of sheared slates and graywackes and white, barren-looking quartz stringers.

A few hundred feet east of the tunnel there is a well-defined quartz vein, with an east-west strike and a vertical dip, cutting the schistosity of the slate graywacke country. The width of the fissure varies from 10 inches to 6 feet. The quartz is from 3 to 36 inches wide and in many places fills the entire fissure. Near the upper end of the outcrop the fissure ranges in width from 3 to 6 feet. It contains no well-defined vein, but includes numerous quartz stringers, some

The gangue minerals of the ores include quartz, calcite, a brown-weathering carbonate, feldspar, and chlorite. The metallic minerals are arsenopyrite, pyrite, pyrrhotite, chalcopyrite, and gold. Limonite is present as a surficial oxidation product of the sulphides.

North Star claim.—The North Star claim is on the north side of Avery River, some distance west of the veins of the Sweepstake Mining Co. The vein is reported to have been located in 1911 by John E. Groth, Thomas J. Davis, E. S. Malone, Harry Thisted, William McKnight, Charles Stevens, and Felix Wilson. The development work consists of a 53-foot incline shaft with two short drifts, 10 and 15 feet in length, along the lead at the bottom of the shaft, and a crosscut tunnel, 20 feet in length, driven in 1913, at an altitude of about 1,620 feet. The shaft, which is at an elevation of 1,725 feet, is sunk on a fissure striking about S. 60° W. and dipping 60° N. The fissure, 5 feet in width at the surface, is in a sheared slate and graywacke country rock. The fissure filling appears to consist of sheared slates and graywackes, with closely packed stringers and lenses of quartz lying parallel to the fissure walls. The ore ranges in width from 6 to 30 inches but is said to average about 2 feet. The lead is reported to outcrop in spots for about the length of a claim. The quartz is said to pan well and to give good assay returns.

Morning Star claim.—Information regarding the Morning Star claim, which was not visited, was obtained from John E. Groth, who, with E. S. Malone, discovered it July 25, 1913. A 10-foot shaft has been sunk on a vein, which shows a width of 4 feet in the bottom of the shaft, though in other places it is much narrower. It is said to be traceable for 3 claim lengths. The Morning Star claim is about 2 claims distant from the North Star claim.

Consolidated claims.—The information regarding the Consolidated claims, which were not visited, was furnished by John E. Groth. They are on the north side of Avery River and adjoin the Morning Star claim. The owners in 1913 were said to be John E. Groth, T. J. Davis, H. Thisted, E. S. Malone, William McKnight, and Charles Stevens. The development work consists ot a 10-foot shaft on a vein striking northeast and ranging in width from 6 inches to 2 feet.

GOLDEN AND VICINITY.

Nugget claim.—The Nugget claim is above timber line, at an elevation of 1,700 feet on the mountain northeast of Golden. The veins were discovered by Stephen Roe August 14, 1911. No development work was done in 1911. The development work in 1913 consisted of a tunnel with about 175 feet of underground workings, a shallow shaft at the upper showing (original discovery), some stripping, and a trail from the shore to the property. A shipment of ore from both showings is reported to have yielded good returns.

The country rock of the ore bodies is graywacke and black slate. The two ore bodies are about 700 feet apart. The original discovery is reported to be a 4 to 10 inch vein, traceable 70 feet, with a northeast strike and nearly vertical dip. The tunnel is driven on the lower showing, a fissure 4 to 30 inches wide, with a length of about 200 feet. At the mouth of the tunnel this fissure strikes N. 80° E. and dips 75° N. At the east end of the vein the lead makes a curve southward, the last 10 feet having a northerly strike and a vertical dip. The fissure filling consists of sheared slate and graywacke. The quartz in the fissure varies from only a little in places to a solid vein 20 inches wide. The gangue is quartz, with some calcite and considerable chlorite. The metallic ore minerals include gold, silver, galena, and pyrrhotite. The ore is said to contain chalcopyrite and pyrite. Limonite occurs, as usual, as an alteration product of the iron-bearing sulphides.

Mayflower vein.—The Mayflower lead crosses the crest of the mountain northeast of Golden at timber line. Only a little open-cut work on the lead is reported. The country is the usual slate and graywacke. The lead is an 8-foot fissure, striking southwest and dipping 70° W. Stringers of quartz, from 2 to 8 inches in width, are reported in the sheared fissure filling. Low assays are reported.

Golden Wonder No. 9 claim.—The Golden Wonder No. 9 claim is above timber line on the mountain northeast of Golden, about 1½ miles from the town. The vein is said to have been located July 31, 1911, by Charles Anderson and Louis Little. The developments consist of a deep 30-foot open cut along the lead at an elevation of 1,440 feet, and some stripping. The country rock is chiefly slate with some massive graywacke. The beds are folded and sheared. The ore lies in a well-defined fissure striking southwestward and dipping 70° N. The fissure ranges in width from 8 to 44 inches, and is traceable for over 250 feet. The fissure filling consists of crushed slate, in some places with little or no quartz. In other places quartz occurs as long and narrow stringers and lenses lying parallel to the walls of the fissure. At the open cut the fissure is 44 inches wide and contains a 3-foot quartz lens about 100 feet long. The hanging wall side of this large quartz lens is smooth and shows horizontal slickensides, and there is an inch of gouge on the hanging wall.

The nonmetallic ore minerals include quartz and small amounts of calcite and chlorite. The gold is free. The sulphides are present as tiny specks in the ore and include pyrrhotite, pyrite, chalcopyrite, arsenopyrite, and sphalerite. Limonite occurs as a surface alteration product of the sulphides. Assays ranging from $30 to $100 are reported on this ore.

Frodenburg & Bloom claim.—The Frodenburg & Bloom claim is at an elevation of 1,150 feet on the mountain northeast of Golden. It is near the Golden Wonder No. 9, and was located Jul [illegible] by Axel Frodenburg and Charles Bloom. The only development work consists of a little stripping. The country rock is chiefly graywacke. The fissure strikes S. 80° W. and dips 60° N. At one place a quartz lens, 10 to 18 inches wide and traceable 45 feet, fills the entire fissure. About 50 feet farther uphill a 25-foot stripping exposes a 10-inch fissure in graywacke with 8 inches of quartz. A few fine colors are reported to be obtainable from this quartz by panning.

Mountain claim.—The Mountain claim is located on a fissure that is reported to be the extension of the fissure on the Golden Wonder No. 9 claim. It is at an elevation of about 450 feet in the timber on the mountain northeast of Golden. The country rock is slate and graywacke. The development work in 1913 consisted of open cuts and stripping. The fissure is about 8 feet wide, strikes S. 70° W., and dips 85° W. Numerous small quartz stringers and bunches of quartz lie in the fissure filling, parallel to the walls. Most of the stringers are short and the largest have thicknesses of 2 to 3 inches. The ore contains much vein chlorite.

Lucky Swede claim.—The Lucky Swede vein is at the foot of the south slope of the mountain northeast of Golden, a short distance from the town. The lowest outcrop is at an elevation of about 800 feet. The vein was discovered and located in the summer of 1911 by Charles Anderson and Louis Little. The development work in 1913 consisted of a little stripping and trail cutting. The country rock comprises slate and graywacke. The ore body is a quartz-filled fissure striking S. 60°–70° W. and dipping steeply to the southeast (77°–85°). The vein is traceable for several hundred feet. Its width varies from 8 to 44 inches. The maximum width of solid quartz is 36 inches, but the average width is only 2 feet. The fissure in some place includes a little sheared slate and graywacke. The walls of the vein are in most places frozen. Where the walls were free no gouge was observed. The quartz shows a little secondary banding parallel to the walls.

This vein is only slightly mineralized. The ore pans free gold and assays ranging from $1 to $14 are reported. No sulphides were seen in the ore.

Golden Wonder No. 1 claim.—The Golden Wonder No. 1 is a short distance east of Golden, at the foot of the mountain, on the northeast side of the town. It was discovered and located July 31, 1911, by Charles Anderson and Louis Little. The development work in the fall of 1913 consisted of a 10-foot adit tunnel with a 15-foot approach, at an elevation of 350 feet, and some stripping along the ledge. A ton of the ore is said to have been shipped to Tacoma.

The country rock is the usual slate and graywacke. The ore body lies in a fissure that is reported to be traceable for more than 2,000 feet. The fissure strikes S. 60° W. and dips 70° N. and varies in width from 2½ to 4 feet. The fissure filling consists of shattered and sheared slate and graywacke with lenses and stringers of quartz parallel to the walls. At the tunnel the quartz ranges from narrow seams to stringers 8 inches wide. The stripping at the discovery exposes the lead for about 75 feet. Here the quartz ranges in width from 1 to 6 inches. At an elevation of 590 feet only a few quartz stringers show in an 8-foot strip of the fissure. The maximum width of solid quartz reported is 10 inches.

The quartz is hard and bluish white. Secondary banding parallel to the walls appears in places. A small amount of calcite occurs as a gangue mineral. The metallic minerals recognized in the ore are gold, galena, and arsenopyrite. The fissure filling is said to assay $4 to $5 in gold per ton, and assays as high as $96 per ton are reported from the quartz.

Arrowhead claim.—The Arrowhead claim was located by H. C. and H. R. Johnson January 1, 1913. It is on the shore south of Golden near the entrance to the small bay on which Golden is situated. The development work at the time of the writer's visit comprised a 20-foot adit tunnel, a little stripping, and a cabin. The country rock is slate and graywacke. The tunnel is driven S. 70° W. along a vertical fissure parallel to the shore. The width of the fissure varies from 6 inches to 8 feet, and it appears to be traceable for several hundred feet. The fissure filling consists of sheared slate carrying quartz stringers parallel to the walls. The amount of quartz in the tunnel varies from a few stringers to a mass that is reported to fill the entire face of the tunnel. On the shore along the line of the fissure there is a quartz outcrop 125 feet long by 8 feet wide, with 2 feet of slate and with quartz stringers on the east wall. This quartz occurs as closely packed lenses. The ore appears to be only slightly mineralized. It contains few sulphides, only pyrite having been observed.

Griset claims.—Along the shore near Golden Edwin Griset has located several claims on which little development work has been done. A 6-foot shaft has been sunk on a lead that is traceable for about 75 feet. A quartz lens 5 feet thick outcrops on the shore. The shaft exposes an 18-inch vein of white quartz that strikes southwest and dips north on one side of the shaft. A mass of shattered graywackes 32 inches wide, with quartz seams, forms the opposite side of the shaft. A 10-foot tunnel just west of the post office crosscuts a 33-inch fissure striking S. 65° W. and dipping 55° N. The country rock is the usual slate and graywacke. The fissure is reported to be traceable about 300 feet. Gouge occurs on both walls and quartz lenses and stringers appear in the fissure filling. About 22 inches of quartz shows in the north wall of the tunnel but only a few quartz stringers in the fissure on the south wall.

The Keynote claim is about a mile south of Golden and about 400 feet from the shore, on the north bank of a small stream, at an elevation of 75 to 100 feet. This claim was located September 7, 1913, and at the time the property was visited the lead had been stripped about 40 feet. The vein ranges in width from 3 to 6 feet. The quartz in surface showings is much shattered and breaks free from the hanging wall with a little gouge. Bunches of quartz also occur in the country slate and graywacke. Sulphides are scarce in the ore, and arsenopyrite and pyrite were the only ones recognized. The ore pans fine gold.

Golden Eagle claim.—The Golden Eagle lode outcrops on the steep timbered north slope of the mountain south of Golden, between 500 and 600 feet above sea level. This prospect is said to have been discovered late in August, 1911, by Charles Anderson and Louis Little. A large gold-bearing quartz bowlder, weighing about a ton, was found on the south side of the lagoon on this claim. This bowlder was broken up and shipped to the stamp mill at Valdez in September, 1911, and is reported to have yielded $42. A shipment of ore is also reported to have been made from this property in 1913. The development work consists of two tunnels, 155 and 45 feet in length, and a trail to the property from the shore.

The country rocks are black slates and dark-colored graywackes, much folded and faulted. The ore deposit appears to be a stringer lode, in the folded and faulted slates and graywackes. It is reported to be traceable 400 or 500 feet. The lode varies in width from 2 inches to 10 feet or more. At the mouth of the upper tunnel it is about 10 feet wide. In the bluff between the two tunnels no lead shows, the graywacke walls apparently coming together and cutting it out. The lode strikes about S. 20° W. and has a vertical dip. The distribution of quartz is very irregular. Masses of quartz, the largest 18 inches across, occur in the lower tunnel, which is driven in slate along a slate-graywacke contact. The slate carries numerous quartz stringers parallel to the contact. At some places 2 to 4 feet of solid quartz can be seen in the lode; at others the quartz occurs as numerous narrow stringers.

The gangue is predominantly quartz but contains also chlorite. Gold occurs native. Few sulphides are seen in the ore, pyrrhotite being the only one recognized. Assays are reported ranging from blanks to $175 per ton. A 10-foot sample over the mouth of the upper tunnel is said to have assayed $9.20.

H. M. Carter claims.—The O. K. No. 1 and New York claims of H. M. Carter were located in the fall of 1911. They lie north of the Tolson and Stanton prospect, at an elevation of 1,750 feet on the west slope of the mountain south of Golden, about 1½ miles from the settlement. The only development in September, 1913, was a short open cut. The country rock is schistose slates and graywackes. The ore deposit consists of a series of small parallel fissures carrying quartz stringers and lenses. The largest fissure ranges in a width from 4 to 12 inches. The maximum width observed on any body of quartz was 10 inches. The fissures strike S. 70° W. to S. 85° W. and have a vertical dip. The ore carries considerable fine gold and is reported to yield good assays.

Tolson & Stanton prospect.—The prospect of Michael Stanton and C. P. Tolson lies between 1,500 and 1,600 feet above sea level on the mountain about 2 miles south of Golden. It was discovered and located in September, 1911, by the present owners. The development work in September, 1913, consisted of a tunnel about 155 feet in length and some stripping along the lead. An arrastre, a cabin, and a trail to the shore were also built.

The country rock consists of closely folded slates and graywackes. The ore deposit occupies a fissure from 2 to 5 feet wide, which is traceable about 300 feet. The fissure has a southwest strike and a vertical dip. The fissure filling consists of sheared slate and graywacke with stringers and lenses of quartz parallel to the walls of the fissure. The amount of quartz in the fissure varies from place to place. The widest quartz lens or stringer was 24 inches across. At an elevation of 1,620 feet a 10-inch quartz stringer extends into the west wall of the fissure. At an elevation of 1,660 feet a line of quartz outcrops extends 50 feet southwestward from the fissure. In places only a few small quartz stringers occur in the fissure.

The gangue minerals are quartz, calcite, and chlorite. The metallic ore minerals are gold, arsenopyrite, sphalerite, pyrite, and pyrrhotite. Some arsenopyrite impregnates the slate country rock.

BARRY ARM.

Paymaster lode.—The Paymaster lode was not visited, and the information regarding it given here was obtained from the locator, Peter Black, who discovered and located it in the fall of 1912. It is above timber line on a mountain on the east side of Barry Arm, about 1½ miles from the shore. The vein is reported to strike about north and to be traceable for 200 to 300 feet. Its width ranges from 1½ to 3 feet. Pans and assays of gold ranging from $18 to $88 per ton are reported.

Walters, Brasslin & Atkinson prospect.—The prospect of A. W. Walters, J. Brasslin, and Robert Atkinson is 1½ miles from Barry Arm, on the west side of a stream that flows into Barry Arm just west of Point Pakenham. Float was found in 1911 in a small creek that crosses the ledge, which was discovered July 2, 1913. A lower crosscut tunnel, 52 feet long, at an elevation of 265 feet, an upper adit tunnel, 25 feet long, at an elevation of 300 feet, open cuts, and stripping comprised the development work in September, 1913.

The country rock is the usual slate and graywacke. The ore deposit is a small vein, which is traceable about 170 feet. At the upper tunnel the vein ranged in width from 2 to 8 inches, but its average width was about 3 inches. It strikes N. 21° E. and dips vertically at the tunnel and shows a thin gouge on both walls. At one place it is offset 2 feet by a small fault. About 20 feet south of the mouth of the tunnel the course of the vein swings round to N. 40° E. A few barren-looking quartz stringers occur in different parts of the lower crosscut tunnel. The vein, which is crosscut at the face of this tunnel, has a strike of N. 11° E. and a vertical dip. The east wall is free, with gouge; the hanging wall is frozen. Arsenopyrite occurs in considerable quantity in the ore, some stringers of solid arsenopyrite an inch thick being seen. The other metallic ore minerals are galena, gold, and sphalerite. The oxidized outcrop of the ore body is reported to yield big pans. Assays of the ore are said to range from $23 to $88.

Simonton & Mills prospect.—The prospect of J. L. Simonton and Fred Mills is in the timber on the northeast side of Barry Arm, about a mile from shore, at an elevation between 900 and 1,000 feet. The Alaska Wonder ledge was discovered and staked July 4, 1913. The development work consists of stripping the vein and cutting a trail to the property. The country rock is graywacke and some slate. The ore body has been traced about 200 feet. It varies in width from 6 inches to 5¾ feet of solid quartz. The walls are in most places frozen, but in some places break free, without gouge. The lead strikes a little west of north and has a vertical dip. At an elevation of 1,025 feet a nearly parallel 4-foot quartz vein joins this vein. In places these veins consist of shattered graywacke and numerous branching stringers of white quartz. The ore minerals are galena, pyrite, chalcopyrite, and gold.

About 400 feet north of this ledge is a large outcrop of quartz 10 to 12 feet wide, which has been traced for about 50 feet by a series of open cuts. This quartz appears to be but slightly mineralized.

Prospects of Charles Cameron.—The three prospects of Charles Cameron are on Barry Arm, on the west side of Point Pakenham. Two of the prospects are at sea level and close to the shore; the other is in the timber at an elevation of 785 feet, about three-fourths of a mile north of Point Pakenham.

About 200 feet from the shore is a vein, which was located in the spring of 1912. It occupies a small well-defined fissure striking north and dipping 50° E. The width of the vein varies from 4 to 20 inches, averaging between 10 and 15 inches. It has been stripped about 100 feet. The country rock is slate and thin banded argillite. The [illegible] wall of the vein is free but shows no gouge. In the 25-foot tunnel a thin gouge lies along the hanging wall. The vein shows secondary banding parallel to the walls. The quartz is white, and in places is vuggy and contains coarse quartz crystals, though at other places it is fine and compact. The mineralization is slight. Free gold is reported, and calcite, arsenopyrite, chalcopyrite, and pyrite were recognized in the ore. The ore contains also a cream-colored carbonate with curved cleavage surfaces.

Near by on the shore another quartz vein is exposed in a 15-foot vertical bluff. This vein was located June 30, 1912. The country rock is slate and graywacke. The strike is apparently N. 45° W.; the dip is 20° N. at the foot of the bluff and 60° N. at the top. The width of the vein ranges from 8 to 15 inches. The walls are free but show no gouge.

The Last Chance No. 2 claim was staked May 2, 1913, by Charles Cameron. It is at an elevation of about 775 feet on the north bank of a small creek about three-fourths of a mile north of Point Pakenham. The country rock is massive graywacke and a little slate. The vein strikes S. 10° W. and dips 50° W. and varies in width from 3 to 36 inches. It has been traced about 150 feet. The walls are free but show no gouge. A slight secondary banding parallel to the walls is evident in some places. The quartz is white, is vuggy in spots, and contains large quartz crystals and a few specks of arsenopyrite. The ore is said to pan good and a $13 assay is reported.

Griset & Benson claim.—The property of Edwin Griset and O. T. Benson, on the east side of Point Pakenham, was not visited, and the information here given was obtained from Edwin Griset. It includes Eureka and Spruce groups, which were located in the spring of 1912. The developments consist of a 30-foot crosscut tunnel, open cuts, and stripping. The ledge has been traced about 300 feet and shows an average width of 3 feet of quartz, with a maximum width of 7 to 8 feet. The vein has a nearly vertical dip.

Mitchell & Myers mineralized dike.—The property of J. E. Mitchell and W. H. Myers is on the south side of Mitchell Creek, a tributary to Barry Arm from the south near the mouth of the arm. The claims are timbered. The lowest outcrop of the ore body is about 30 feet above sea level. The property was discovered September 2, 1912, by the present owners. The development work consists of a few open cuts. An acidic dike, 67 inches wide at the lowest showing and 5 feet wide at the upper showing, cuts the slate country. The dike strikes S. 50° W. and dips 53°–75° W. and is reported to be traceable four claim lengths. Between the two showings visited, a distance of about 1,000 feet, the dike is concealed. The ore deposit consists of [illegible] veins and stringers cementing the shatt[illegible] gold-bearing quartz stringers [illegible] walls, occur in the dike. At an elevation of 180 feet a quartz vein 3 inches wide, with free walls, strikes N. 51° W. and dips 60° E. A few quartz stringers with frozen walls also occur here. The gangue minerals of the ore are quartz and calcite. The metallic ore minerals are arsenopyrite, galena, and gold. Pyrite is also reported. Assays on the dike alone are said to range from $1.40 to $7. Higher assays are reported on the quartz.

HARRIMAN FIORD.

Black & Hogan prospect.—The prospect of Peter Black and William Hogan was located in August, 1913, on the north side of Harriman Fiord, a short distance east of the foot of the Serpentine Glacier. The claims are timbered. Newspaper accounts state that a 200-foot adit tunnel was driven on one of the veins during the winter of 1913–14.

The country rock consists of graywacke cut by much altered light-gray fine to medium grained granite dikes and masses. Several nearly parallel quartz veins are reported. At an elevation of 350 feet an 18-inch quartz-filled fissure strikes N. 26° W. and dips 73° W. in graywacke. Faint secondary banding parallel to the walls shows in places. This vein is stripped to an elevation of 400 feet. A few hundred feet northeast of this vein is a second vein, 10 to 14 inches wide, striking N. 20° W. and dipping 67° W. in a graywacke country rock. Secondary banding parallel to the walls shows in places. The walls are free. The lowest showing on the property is at an elevation of 110 feet. This vein cuts a massive graywacke ledge and a vertical granite dike 6 feet in width. A large granitic mass is intrusive into the graywacke about 100 feet east of the vein. The width of the vein varies from 2 to 8 inches. The strike is N. 15°–40° W. and the dip is 77° E. to vertical. The ore contains galena, gold, arsenopyrite, and sphalerite.

Prospect of J. W. Reiter and M. J. Olson.—The prospect located by J. W. Reiter and M. J. Olson on Point Doran about August 27, 1913, was not visited. The information regarding this property was obtained from J. W. Reiter. The vein is located within 500 feet of the tip of the point. The quartz ledge ranges in width from 8 inches to 3 feet and is reported to be traceable about 200 feet. The same partners own two claims farther up Harriman Fiord, on which there are said to be six parallel veins in graywacke. These veins show from 8 to 30 inches of quartz. Stibnite occurs in one of the veins and chalcopyrite and galena in another.

Sweepstake Mining Co.—The property of the Sweepstake Mining Co., on Harriman Fiord, is above timber line on the south side of the fiord, near its head, at an elevation of about 600 feet. The vein, known as the Imp, is said to have been discovered in July, 1912, by Chris Pedersen and Ole Hanson. Development work began in

November, 1912, and ceased in February, 1913. In August, 1913, the developments consisted of a 150-foot tunnel and some stripping along the vein. The country rock comprises interbedded slates and graywackes, thin bedded in places, in others principally graywacke, cut by numerous acidic dikes 6 to 48 inches thick. The vein fissure crosses one of these dikes at the mouth of the tunnel. The vein is well exposed for about 150 feet. It strikes east and dips 85° N. at its upper end, and strikes S. 84° W. and has a vertical dip at the lowest exposure. The width varies from 1 to 5 feet. The upper or east half of the outcrop averages 3 feet in width; the remainder of the vein ranges in width from 10 to 18 inches. The walls are free in some places and frozen in others. No gouge is visible. The quartz vein filling appears to stop at the dike, and irregular bunches and stringers of quartz cement the shattered dike. The narrower parts of the vein are the more mineralized. Secondary banding parallel to the walls is also prominent in the narrow part of the vein. Gold, arsenopyrite, pyrite, sphalerite, galena, chalcopyrite, stibnite, calcite, and quartz were observed in specimens taken from the outcrop and obtained from the tunnel dump.

Prospect of White & Jones.—The Skypilot ledge, located by Frank White and Harold Jones in September, 1912, is on the north side of Harriman Glacier, about 600 feet above sea level. This prospect was not visited, the information given regarding it having been furnished by Frank White. The country rock is conglomerate and slate. The vein is reported to be traceable 450 to 500 feet and to range in width from 2 feet at the lower end to 5 feet at the upper. Gouge occurs on both walls. The vein is said to strike northwest and to have a vertical dip. The ore pans free gold and is said to assay well.

PORT WELLS.

HARRISON LAGOON (HARRIS SLOUGH).

Olsen & Viette claims.—The Dominick ledge is about 2 miles from Port Wells, at an elevation of 1,300 feet, on the north side of a cirque at the head of a creek draining into Harrison Lagoon. The lead is above timber line. It was located in September, 1912, by Hogan Olsen and Dominick Viette. The developments in the fall of 1913 consisted of a short crosscut tunnel, some stripping, and a trail to the shore. Eight men were at work on the property at that time.

The country rock consists of argillites and graywackes intruded by a large dike or boss of medium-grained light-gray igneous rock. The ore deposit lies in a well-defined fissure, 3 to 4½ feet wide, with a strike of S. 30° W. and a dip ranging from 80° E. to vertical. This fissure is reported to be traceable about 2,000 feet. The shear zone carries considerable waste material and at no place is the fissure filling known to be all quartz. A maximum of 2 feet of quartz is reported. The shattered fissure filling is in places silicified and cemented by the quartz. Gouge occurs on both walls, ranging from thin seams to layers 4 inches thick. Quartz, calcite, pyrite, sphalerite, gold, and chalcopyrite occur in the ore. The gold is all fine.

SHORE BETWEEN HARRISON LAGOON AND HOBO BAY.

Granite Gold Mining Co.—The property of the Granite Gold Mining Co., better known locally as the Tatum property, is on the west side of Port Wells on an eastward-facing timbered slope bordering a small bight in the coast between Hobo Bay and Harrison Lagoon. The original discovery, at an elevation of about 580 feet, is on the end line between the Port Wells No. 1 and the Port Wells No. 2 claims. A trail extends from the shore to the workings.

The vein was discovered July 19, 1912, by M. L. Tatum and Jonathan Erving, and a shaft was sunk on the vein. About 5 tons of ore taken from the shaft are said to have been shipped in December, 1912. The developments August 22, 1913, included a 30-foot incline shaft, a 170-foot crosscut tunnel with 2 drifts on the vein, 75 and 60 feet long, 150 feet from the mouth of the tunnel; surface stripping; and a log cabin. The Granite Gold Mining Co. was incorporated later, additional underground development work was done, and a mill was erected during the winter of 1913–14.

The country rock consists of interbedded slates, graywackes, and blue-black argillites cut by large masses of considerably altered medium-grained light-gray to greenish-gray granite. The ore deposit occupies a fissure striking S. 75° W. and dipping 60° N. in the shaft and striking N. 50°–72° W. and dipping 43°–55° N. in the tunnel and drifts. The width of the fissure varies from 3 inches to 3 feet and greater widths are reported in recent developments. The lead is traceable on the surfaces about 150 feet. The walls are free, gouge showing on both walls in the upper part of the shaft. The walls in the shaft are slate and graywacke. In the tunnel and the drifts the hanging wall is granite. The fissure filling is shattered graywacke, quartz veins or a quartz network cementing the shattered graywacke and inclosing the angular graywacke fragments in a network of porous white crystalline quartz.

The gangue minerals include quartz, calcite, and a brownish-weathering carbonate. The quartz is open textured, like a mass of interlocking crystals. The metallic ore minerals are gold, pyrite, sphalerite, stibnite, galena, arsenopyrite, and chalcopyrite. High assays are reported from some of this ore.

HOBO BAY.

Reed, Gauthier & Cooper prospect.—The prospect of F. W. Reed, Burt Gauthier, and H. B. Cooper is on the south shore of Hobo Bay near its head. It was located in June, 1912, by the present owners. The developments in September, 1913, included a 160-foot crosscut tunnel at an elevation of about 40 feet, a shallow shaft on the lead about 60 feet above the tunnel, open cuts, stripping, a 25-foot adit tunnel on the shore, a 30-foot winze in this tunnel, and a log cabin.

The country rock consists of interbedded black slate and dark-gray graywackes. The ore body occupies a fissure, which has been stripped at intervals for 800 or 900 feet. The fissure strikes between S. 30° W. and S. 60° W. and dips about 70° N. It ranges in width from 30 to 36 inches. The fissure filling is crushed slate and graywacke with quartz stringers and lenses. The proportion of quartz varies in different places in the fissure. The width of the quartz lenses ranges from 3 to 14 inches. One 8-inch lens was traceable 25 feet. Quartz, calcite, pyrrhotite, chalcopyrite, sphalerite, and pyrite occur in the ore, which is also reported to assay well in gold.

BETTLES BAY.

Yakima ledge.—The Yakima ledge is on the north shore of Bettles Bay near its head. It was located June 12, 1912, by Joshua Brereton, Teunes Oome, and Ben Howell. The developments include a 25-foot tunnel and some stripping. The country rock is graywacke and slate. The tunnel is driven along a vein striking N. 12° E. and dipping 80° W. This vein has been traced 60 feet. The width of the fissure ranges from 10 to 31 inches and the width of the contained quartz ranges from 10 to 31 inches also, although in places there is as much as 15 inches of crushed slate fissure filling. Secondary banding parallel to the walls is evident in places. The walls are free and the hanging wall in places shows heavy gouge. The ore contains quartz, calcite, gold, pyrite, sphalerite, arsenopyrite, galena, chalcopyrite, and pyrrhotite.

Hermann & Eaton prospect.—The Hermann & Eaton prospect is on Eaton Creek about a mile northwest of the head of Bettles Bay. This property, known as the Mineral King group, is said to have been located by George H. Hermann June 4, 1912. The developments include an incline shaft, reported to be 117 feet deep, a 65-foot drift on the vein at the bottom of the shaft, some stripping on the lead, a shaft house covering hoisting engine, pump, and boiler, and a trail from the shore to the property.

The country rock is fine-grained dark-gray graywacke and argillite. A large dike is reported to cut these metamorphic rocks about 100 feet from the vein. The ore deposit occupies a fissure and is traceable about 200 feet. The fissure strikes N. 26° W. and dips 45° E. at the surface and 50° E. in the lower part of the shaft. The width of the fissure filling is from 2 to 6 feet and averages about 3 feet. The proportion of quartz to shattered graywacke in the filling varies. The fissure is exposed in the stream 75 feet west of the shaft, where its filling is about 4 feet wide and consists mostly of quartz but includes some graywacke. Twenty-five feet below the collar of the shaft 13 inches of quartz occurred in a 30-inch fissure. At 60 feet the fissure was 23 inches wide, 19 inches of which was quartz. The quartz veins parallel the walls and there are very few cross fractures. Large lenses of quartz 15 to 25 feet long overlap, pinch out, or play out into stringers which in places unite with similar stringers from other lenses to form veins, or the stringers themselves widen until they are several inches across. The hanging wall of the fissure shows no gouge and most of the quartz veins break free from the graywacke with no gouge. The ore contains quartz, calcite, sphalerite, pyrite, galena, chalcopyrite, gold, pyrrhotite, and arsenopyrite.

George & McFarland prospect.—The prospect of Harry George and J. W. McFarland is on the south shore of Bettles Bay near its head. It was located September 30, 1911. The development work includes a 45-foot tunnel, a winze reported to be 40 feet deep in the tunnel, some stripping, and a cabin. The country rocks are slates and graywackes, which are intruded by acidic dikes. The lead has been traced about 50 feet. The tunnel is driven S. 26° E. along a fissure dipping 70° N. A narrow acidic dike is cut by this fissure at the winze. At the mouth of the tunnel are two sets of quartz-bearing fissures. The width of the quartz varies from 1 to 12 inches, and the stringers are short. The ore contains quartz, gold, pyrite, and galena.

HUMMER BAY

Prospect of Everson, Harris & Parker.—The Hummer vein is about three-fourths of a mile northwest of the head of Hummer Bay on the south side of the valley, at an elevation of 400 feet. It was discovered June 10, 1912, and located June 15, 1912, by C. W. Everson, Fred Harris, and A. Parker. The developments include a 40-foot tunnel with a 15-foot approach, a winze of unknown depth in this tunnel, and some stripping. The country rock consists of slates, argillites, and graywackes. The ore deposit consists of numerous irregular quartz stringers in folded, faulted, and sheared slates, argillites, and graywackes. A width of about 10 feet of this stringer lode is exposed. The general strike is from S. 10° W. to S. 40° W., and the dip is 60° W. The quartz stringers are in general parallel to each other and to the strike of the lode. These stringers range in thickness from 1 to 12 inches. The longest stringer is traceable about 60 feet, its width varying from 3 to 12 inches. The winze is sunk on this stringer. Some of the stringers break free; others have frozen walls. The mineralization appears slight. Quartz, a cream-colored, brown-weathering carbonate, gal[illegible], and chalcopyrite were recognized in the ore.

PIGOT BAY.

Westburg & Domenzet prospect.—The Tomboy ledge of Isaac Westburg and Joseph Domenzet was not visited. The following information regarding it was furnished by Joseph Domenzet. The vein is at an elevation of about 2,500 feet on the ridge north of Pigot Bay. It is about 3 miles from Port Wells. The trail to the prospect leaves the head of a small bay between Hummer and Pigot bays. The vein was located July 24, 1912. The developments consist of a 16-foot tunnel and some stripping. The vein has been traced about 250 feet and ranges in width from 1 to 28 inches. About 100 feet of the vein will average 22 inches in width. A specimen of the ore furnished by Joseph Domenzet contained quartz, gold, galena, and limonite.

Dunklee & Reilly prospect.—The Black Bear and Yellow Horse claims of E. A. Dunklee and J. J. Reilly are on the north side of the Pigot Glacier stream valley, a mile or more northeast of the head of Pigot Bay, at an elevation of about 700 feet. These claims were located July 7, 1913. The developments comprise a 5-foot tunnel with a long approach, some stripping, and a trail to the head of Pigot Bay. The country rock is argillite cut by acidic dikes. The vein lies in a small well-defined fissure, which cuts the argillites and a 9-foot dike. The fissure strikes S. 63° W. and dips 60° N. It is traceable for about 250 feet. The average width is probably less than 6 inches, but the vein shows from 1 to 24 inches of quartz in different places. The walls are free and in one place 3 inches of gouge was observed. Secondary banding parallel to the walls is evident in places. The ore contains quartz, calcite, chalcopyrite, gold, pyrrhotite, galena, arsenopyrite, and sphalerite.

PASSAGE CANAL.

The prospects on Passage Canal were not visited, but some information regarding them was obtained from prospectors who had seen them. They are all on the north side of the fiord and according to the descriptions include gold-quartz veins, stringer lodes, and a mineralized acidic dike. The rocks on the north side of the Portage Glacier Pass are in places slightly mineralized.

Bullion ledge.—The Bullion ledge is near the east side of the foot of Billings Glacier and is about three-fourths of a mile from shore. The information regarding this property was furnished by Teening Carlson. The lode was located in 1911 by Albert Nordstrom, Teening Carlson, and George Furman. It is of low grade and is apparently a stringer lode in slate. The mineralized zone is reported to be a belt of slate 3,000 feet long and 1,200 feet wide, with numerous quartz stringers 1 to 18 inches wide from 1 to 10 feet apart in the slate. Fine [illegible] gold is reported in the ore.

Hillside vein.—The following information regarding the Hillside vein was furnished by John P. Hansen, who with James Young located the property August 28, 1913. The vein is at an elevation of about 1,000 feet near the head of a westerly tributary of the Billings Glacier stream. The vein is said to be 30 feet in length and 3 feet in width in the widest place. A specimen of the ore furnished by Mr. Hansen contained quartz, gold, pyrrhotite, chalcopyrite, sphalerite, and galena.

Prospect of Ernest King.—According to information furnished by Ernest King, who discovered this vein August 23, 1913, it is on the north side of Passage Canal a quarter of a mile from the head of the bay, at an elevation of 700 feet. It is 100 feet in length and has a maximum width of 1 foot. The walls are said to be free.

Collins, Fish & Barry prospect.—A mineralized dike near the east side of the foot of Billings Glacier was located in August, 1912, by Philip Collins, G. Q. Fish, and George M. Barry. The country rock is slate and graywacke. The ore body is reported to be a mineralized dike 1½ to 5 feet in width, which is traceable several thousand feet. The seams of quartz, which occur in fractures in the dike, vary greatly in thickness, the widest measuring 8 inches. The ore is said to pan well. It contains quartz, calcite, a cream-colored, brown-weathering carbonate, arsenopyrite, and galena. The dike is greatly altered.

ESTHER ISLAND.

Kavanaugh & Boon prospect.—The prospect of H. C. Kavanaugh and August Boon is on the west side of Esther Island a short distance south of a large bay. It was located September 12, 1911. The only development consists of a 5-foot tunnel at an elevation of 375 feet. A shipment of ore is reported to have been made from this property. The ore deposit lies within the contact zone of the Esther granite. The ore body examined was a shattered graywacke bed cemented by irregular bunches and stringers of fine-grained dense white quartz, which is tightly frozen to the graywacke. The ore body exposed at the tunnel is about 20 feet long and 6 feet wide. The strike is southwest; the dip is vertical. A narrow ill-defined zone of bluish quartz, 1 to 4 inches wide, along the west wall carries considerable free gold. The ore contains quartz, chlorite, gold, pyrrhotite, galena, chalcopyrite, and pyrite.

Prospect of Fish, Collins & Stewart.—The prospect of G. Q. Fish, Philip Collins, and E. D. Stewart is on the southwest part of Esther Island, at an elevation of 800 feet, about a mile from the shore. It was located in September, 1912. The underground development work consists of a 40-foot adit tunnel. The ore deposit lies within the contact zone of the Esther granite and the country rock consists of contact-metamorphosed argillites and graywacke. The ore body lies in a fissure striking N. 7°–22° E. and dipping 85° W. to vertical. It is traceable about 100 feet and ranges in width from 44 to 56 inches. The walls are well defined, gouge appearing on both walls. In the tunnel little quartz shows in the fissure except a vein 1 to 4 inches wide, which lies along the hanging wall, but 2 feet of quartz is reported in one of the surface showings. The ore consists of fine grained bluish-white quartz carrying gold, pyrrhotite, and chalcopyrite.

EAGLEK BAY.

Eldorado ledge.—The Eldorado ledge is on the south shore of a small bay on the west side of Eaglek Bay. The lowest outcrop is at an elevation of 600 feet. The vein was located in June, 1913, by Frank White and Chris Pedersen. The country rock is slate and graywacke. The ore deposit lies in a fissure 12 to 48 inches wide, which forms a pronounced gulch in the mountain side. This fissure strikes approximately S. 40° W. and dips 75° N. and outcrops for 400 feet. The hanging wall is massive graywacke. The fissure filling is sheared and shattered slates and graywacke with quartz stringers and lenses. The amount of quartz in the fissure filling varies. A maximum width of 2½ feet of quartz is reported. At some places the fissure contains no quartz. The ore has a bluish-gray appearance. Assays on the fissure filling are said to show $4 to $5 in gold; assays on the quartz are reported up to $100. Specimens of this ore were assayed for platinum for the Geological Survey with negative results. The minerals in the ore include quartz, calcite, gold, arsenopyrite, pyrrhotite, and pyrite.

CULROSS ISLAND.

Thomas-Culross Mining Co.[1]—The property of the Thomas-Culross Mining Co. is on the south side of Thomas Bay (Eagle Harbor), about 1,500 feet from the shore. The lead was discovered and located in 1907 by Albert Nordstrom, Teening Carlson, Ludwig Christiansen, and two others, but was not held by them. On October 2, 1910, the ground was relocated as the Bugaboo No. 1 and Bugaboo No. 2 claims by Ludwig Christiansen, N. L. Thomas, and M. G. Thomas. The developments on the property include a 140-foot crosscut tunnel at an elevation of 230 feet, two shallow prospect shafts on the vein, some trenching, and a frame bunkhouse erected at the bay shore. Five tons of ore is said to have been shipped to Tacoma from this property.

The lead so far as traced is all in greenstone. Slates and graywackes show in a stream bed about 50 feet north of the tunnel mouth, and everything north of that point appears to consist of slates with sandy phases and a few beds of graywacke. The greenstone-slate contact is not visible.

---

[1] Considerable information regarding this property was furnished by W. L. Taylor.

The ore body lies in a fissure in greenstone. This fissure is traceable 800 to 900 feet and is 36 inches wide. It strikes about S. 10° W. and has a vertical dip. Stringers and lenses of quartz occur in the sheared greenstone fissure filling. When the shear zone was cut in the tunnel only a few stringers of quartz, 1 to 3 inches wide, were found in the fissure. At one point on the outcrop of the lead, however, a quartz lens 4 to 14 inches wide has been stripped for 20 feet. Some of the quartz shows secondary banding parallel to the walls of the fissure. The country rock is impregnated in places with arsenopyrite crystals. The ore contains quartz, calcite, chlorite, arsenopyrite, pyrrhotite, gold, chalcopyrite, galena, and sphalerite.

Prospect of John Sells.—The Culross No. 1 claim is on the south side of a small bay, on the west side of Culross Island, at an elevation of 725 feet. It is about a mile west of the property of the Thomas-Culross Mining Co. It was located October 5, 1911, by W. B. Harris, and relocated January 1, 1913, by John Sells. The country rock is schistose sandy slates, the schistosity of which strikes S. 30° W. and dips 80° W. The ore body consists of closely grouped quartz lenses and stringers, paralleling the schistosity of the country rock in strike and dip. Irregular stringers and bunches of quartz also occur in the slates. The widths of the quartz lenses range from 4 to 59 inches and the maximum length exposed of any lens or stringer is about 15 feet. The quartz-veined area is about 200 feet in length and has an apparent width of at least 15 feet. Pyrite was the only sulphide recognized in the ore.

MINING ON PRINCE WILLIAM SOUND.

By B. L. Johnson.

GOLD MINING.

WORK OF THE YEAR.

Interest in the gold-mining developments on Prince William Sound in 1913 centered in the Valdez, Tiekel, and Port Wells districts. Considerable development work was in progress and some prospecting was being carried on in these districts in spite of the fact that the placer strike on the Chisana caused a rush of many of the local prospectors to that district during the summer. In the fall there was a rush to the Nelchina placers. The mining developments in the Port Wells district up to and including 1913 are reported elsewhere in this bulletin. In the Tiekel district considerable development is reported on gold-quartz prospects on Hurtle, Glorious Fourth, Boulder and Fall creeks. Gold-quartz prospects have been located at different times on the Prince William Sound shore of Kenai Peninsula, on Blue Fiord, McClure Bay, Jackpot Bay, and Kings Bay. In 1913 some prospecting was in progress, but no active development is known to have been carried on. Gold-bearing gravels are reported on Nellie Juan River.

VALDEZ DISTRICT.

In the Valdez district the Cliff mine was in 1913, as heretofore, the most important producer. The mill, with 6 Nissen stamps, was operated, except for short stops of some of the stamps, throughout the year. About 45 men were employed at the property. Three shifts were worked in the mill and two shifts in the mine. The underground developments are now said to total at least 8,000 feet. Development work was carried forward on the 500-foot level until it was stopped by water, and the pumps were then pulled out and the water was allowed to rise within a few feet of the 300-foot level. In the fall of 1913 mining and development work was in progress on the 100, 200, and 300 foot levels and in the stopes between these levels.

The Gold King, which is about 7 miles from tidewater on Shoup Bay, at an elevation of about 3,800 feet on a nunatak in the Columbia Glacier, made contributions to the gold production of the district in 1913. A 3½-foot Huntington mill, run by gasoline engines, was erected during the spring and summer of 1913. Milling started August 13, 1913, and it is said that between 200 and 300 tons of ore had been milled before the close of the season. Between 25 and 36 men were employed by the company at different times. The underground development work consists of the No. 1 tunnel, with 500 feet of drifts and tunnels, a 60-foot winze, and 90 to 100 feet of drifts from the bottom of the winze; the No. 2 crosscut tunnel, 400 feet in length; the No. 3 crosscut tunnel, 45 feet in length, with 100 feet of drifts, and some open cuts and stripping. A 110-foot raise is reported to have been put in later. The total amount of underground workings is about 1,150 feet of drifts and tunnels, a 60-foot winze, and a 110-foot raise. Several buildings have been erected at the mine and a midway house has been built on the Shoup Glacier. A telephone line connects the mine with the buildings on Shoup Bay.

The Cameron-Johnson Gold Mining Co., on Shoup Bay, installed a 5-stamp mill and concentrator. Power is furnished by a Pelton water wheel. The mill is said to have started late in July, 1913, and to have stopped about October 1, 1913. Nearly 200 tons of ore is reported to have been milled. An average of 30 men were employed on the property during the working season. A temporary tram was erected between the mine and mill; it was later dismantled. Nine tunnels, from 25 to 217 feet in length, are reported, the total work comprising about 1,000 feet of tunnels and 76 feet of raises. Mining was in progress until the middle of September, 1913.

A small 1-stamp mill was run on ore from the Minnie claim, and about 4 tons of ore is said to have been milled. Two men were at work on the property during the summer of 1913. The total developments comprise 35, 20, 15, and 5 foot tunnels and a small cabin.

On the Olson claims, on Shoup Glacier, one man was at work for a part of the season. The developments in 1913 included a 36-foot tunnel, a 130-foot tunnel, a 7-foot shaft, and some stripping and open cuts.

On the Rambler claims 4 men are said to have driven 63 feet of tunnel, making the total length of the Rambler Tunnel 230 feet. It is also reported that an 18 and a 20 foot shaft were constructed.

An adit tunnel 130 feet long is said to have been driven on the Bence-McDonald claims in 1912, but only assessment work was done in 1913.

Two men are reported to have driven two short tunnels, 20 and 32 feet in length, on claims adjoining the Minnie and Bence-McDonald claims.

A 32-foot tunnel is reported to have been driven in 1913 on a claim situated between the Minnie and Cameron-Johnson claims.

At the Alice Mines (Ltd.), on Shoup Bay, development work was stopped early in February. Fifteen men were employed until February 11, 1913. The underground developments are said to comprise a tunnel, a 100-foot shaft, 100 feet of drifts along the lead at the bottom of the shaft, and a raise to the surface from the tunnel level above the shaft.

Four men were employed by the Thompson-Ford Mining Co. in Uno Basin during the first half of the year and one man for the remainder of the season. The underground development work in the fall of 1913 included a lower tunnel, 325 feet long, with 2 drifts, 75 and 25 feet in length; a 150-foot raise from the lower tunnel to the surface; a 20-foot shaft and a 15-foot drift from its bottom to the raise; and about 100 feet of drifts on a level 60 feet below the mouth of the raise.

About 50 feet of underground work by 2 men is said to have been performed on the Guthrie & Belloli property in Uno Basin. The total underground development on this property now consists of a tunnel about 150 feet in length.

The Sea Coast Mining Co., on Shoup Bay, employed an average of 12 men during the summer of 1913. The total underground work in October, 1913, comprised two tunnels, 50 and 238 feet in length, open cuts, and stripping. A large frame building has been erected at the shore, and a small building on the trail to the mine.

Assessment work was done in 1913 on the Bluebird group, near the mouth of Shoup Bay, and the total developments now comprise 115 feet of crosscut tunnel, considerable stripping, a trail to property, and three buildings on the beach. Development work was in progress during the year at the Sealey-Davis property, on Shoup Bay, where two men were at work. Three men were engaged in development work on the Three-in-One property, near the mouth of Gold Creek, in 1913.

On Mineral Creek a 2-stamp mill is said to have been erected on the property of the Mountain King Mining Co. A crew of 15 to 18 men is said to have been employed and considerable development work done. Three tunnels, 50, 130, and 450 feet in length, are reported. Four men were also at work during the summer on the Little Giant group, and two to four men were engaged in assessment and development work on the Millionaire, Hercules, Big Four, Blue Ribbon, Olson & Woods, Williams-Gentzler, Valdez Bonanza, and other claims on this creek.

The Valdez Mining Co., on Valdez Glacier, in 1913, drove about 100 feet additional in its crosscut tunnel, making the total length of the tunnel about 230 feet. The developments on the Ramsay-Rutherford property in October, 1913, are reported to have included a 130-foot shaft and between 400 and 500 feet of tunnels and drifts.

COPPER MINING.

CONDITIONS DURING THE YEAR.

Comparatively little attention was paid to copper prospecting or mining in 1913 in the Prince William Sound region outside of the developed and partly developed properties. The Ellamar and Beatson-Bonanza mines made regular shipments, as in former years, and the Fidalgo Mining Co. joined the ranks of the producers. Large forces of men were maintained at Ellamar and Latouche throughout the year, and a large force was employed at the Midas property during the spring. Eight men were employed continuously at the Fidalgo Mining Co.'s property and several men were engaged in development work by the Fidalgo-Alaska Copper Co. in the spring and fall. Two to four men were engaged in development and assessment work, either continuously or for short periods, on other Prince William Sound copper prospects. An important event of the year in the history of copper mining in this region was the entrance of the Granby Consolidated Mining, Smelting & Power Co. (Ltd.) into the Prince William Sound region through the purchase of the Midas copper property on Solomon Gulch in the Port Valdez district.

VALDEZ DISTRICT.

The Midas property on Solomon Gulch, 4½ miles from Valdez Bay, was bonded in the fall of 1912 to the Alaska Development & Mineral Co. The developments on the property at that time are said to have comprised about 400 feet of underground work. Development work was actively carried on by this company during the winter of 1912–13 and the spring of 1913. Twenty-five men are reported to have been at work on the property in March, 1913. In the later part of June, 1913, when this company gave up its option on the Midas, the underground development work is said to have amounted to more than 1,500 feet of tunnels, drifts, and raises. The principal developments consisted of two adit tunnels, each several hundred feet in length, with a vertical interval between them of 92 feet, and three raises, two of which connect the two levels. No work was in progress in the summer of 1913. In the fall the property was bought by the Granby Consolidated Mining, Smelting & Power Co. (Ltd.), which began preparations for extensive development of the ore body.

ELLAMAR DISTRICT.

The earlier development work at the Ellamar mine was confined to the removal of a rich copper shoot. In recent years other parts of the ore deposit have yielded pay ore, containing gold as well as copper, and at present the entire sulphide deposit is being mined as ore. In 1913 the 400-foot level was unwatered and development work was confined to the 200, 300, and 400 foot levels and the stopes between these levels. The method of mining was changed during the summer, the filling system being then adapted. A new air compressor, installed in the spring of 1913, furnishes air for all underground work. A large 28-room bunkhouse with accommodations for 56 men was completed, a small wireless plant was installed, and a skipway was erected at the end of the wharf for loading the ore directly on board steamers. An average of 40 men worked on the property through the year. Steps were also taken in 1913 to increase the output of this mine.

No ore shipments were made in 1913 from the property of the Threeman Mining Co. on Landlocked Bay, but underground development work was in progress on the A. C. Co., Montezuma, and Keystone claims. Ten men are said to have been employed early in the spring, but this force was later reduced to 4 men. The field work of 1912–13 has demonstrated the presence in ore from the Keystone claim of a copper-iron sulphide, containing about 16 per cent copper, in intimate association with the chalcopyrite. The relative proportions of the two sulphides in this ore are not known.

The Landlock Bay Copper Mining Co. is reported to have had 2 or 3 men engaged in underground development work during a part of the year. Assessment work only was done on other properties in the Ellamar district.

PORT FIDALGO.

Descriptions of the three copper mines on the south side of Port Fidalgo—the properties of the Fidalgo Mining Co., the Fidalgo-Alaska Copper Co., and the Dickey Copper Co.—are included in a forthcoming report on the Ellamar district. Their history and development are summarized briefly here.

The property of the Fidalgo Mining Co. was discovered in 1905 by T. W. Blakney and H. H. Herren. The Fidalgo Mining Co. was incorporated about a year later. During the summer of 1907 the present lower tunnel was driven about 400 feet. In October, 1912, the developments consisted of about 600 feet of underground work. The mine was operated continuously in 1913 with an average crew of 8 men, working one shift each day. The main underground developments at present include a lower adit tunnel 450 feet in length at an elevation of about 850 feet, an upper tunnel 240 feet long, 100 feet above the lower tunnel, a raise connecting these two tunnels, and stopes between the two levels. A 65-foot raise connecting the upper tunnel with the surface is reported to have been put through late in the fall of 1913. A 2,000-foot two-bucket aerial tram was completed early in 1913. The surface improvements on the property include trails, wharf, ore bunkers at the landward end of the wharf, aerial tram connecting the lower bunkers with ore bunkers and sorting house at the upper terminal of the tram, log eating and sleeping quarters at an elevation of 825 feet, log blacksmith shop and log gasoline engine shed at the mouth of the lower tunnel, and a log cabin and shake shed on shore 1,000 feet east of the wharf. A 900-foot surface tram connects the mouth of the lower tunnel with the upper terminal of the aerial tram. The upper ore bunkers are reported to hold about 50 tons. The lower ore bunkers are of logs and have a reported capacity of about 500 tons of ore. The first shipment of ore from this property was made in February, 1913, to the Tacoma smelter. Several other shipments were made later in the year.

The property of the Fidalgo-Alaska Copper Co., better known locally as the Schlosser property, is said to have been discovered in June, 1907, by Charles Schlosser. The Fidalgo-Alaska Copper Co. was then formed and development work was started in the fall of 1907. Considerable underground work has since been done. A small crew of men were at work on the property in the spring of 1913. The property was idle during the summer, but development work was again started in the fall and a shipment of ore is said to have been made to the Tacoma smelter later in the year. Several hundred tons of ore are reported to have been shipped in previous years. The underground workings in July, 1913, comprised the lower tunnel, at an elevation of about 800 feet, with 550 feet of crosscuts and drifts, two stopes, and a raise; a forked tunnel at 950 feet elevation, the tunnel forking at the mouth into two branches 75 and 500 feet in length, with a raise in the long branch; a short tunnel at an elevation of 1,005 feet forking 45 feet from the mouth into two branches 10 and 15 feet long; two shallow shafts, at an elevation of 1,050 feet, one of which extends down into the west branch of the upper forked tunnel; three other short tunnels, a shallow shaft, open cuts, and stripping. The surface improvements included trail, wharf, ore bunkers at wharf, frame building close to ore bunkers, an aerial tram, reported to be 2,800 feet long from the wharf to the mine, and several log buildings at the mine. A portion of the wharf was washed away during the summer of 1913.

The prospect of the Dickey Copper Co., known locally as the Mason & Gleason claims, was discovered by George Mason and Mark Gleason in July, 1907. About 50 feet of underground work had been done when the property was bonded in 1910 to W. A. Dickey, who later bought it. Some development work was done in 1911 and 1912. In the spring of 1913, with 4 men at work on the property, the trail was constructed, ore bunkers were built, 110 feet of tunnel and 70 feet of drift were driven, and about 600 tons of ore were mined. Operations were discontinued July 1, 1913. No ore shipments had been made to that date. The underground developments in July, 1913, included a lower tunnel with several hundred feet of drifts and crosscuts and a raise; an upper tunnel 125 feet long, with a 25-foot raise, and a stope 30 by 8 feet, extending from the tunnel to the surface; an intermediate tunnel 35 feet long between the upper and lower tunnels; a 30-foot winze connecting the upper and intermediate levels; and a short crosscut tunnel on the outcrop of the lead. Surface improvements consisted of a 2-mile trail to the shore of Irish Cove, a small shake warehouse on the shore, a log cabin at the mine workings, two log ore bunkers, with a total capacity of about 800 tons, just below the mouth of the lower tunnel; two shake sheds at the mouth of the lower tunnel; and a log blacksmith shop and a small log ore shed at the mouth of the upper tunnel. The ore mined, about 600 tons, was, in July, 1913, stored in the ore bunkers.

LATOUCHE AND KNIGHT ISLANDS.

The Beatson Copper Co., on Latouche Island, was a regular shipper of copper ore in 1913 to the Tacoma smelter. An average of about 60 men were employed during the year, working two shifts of 8 hours each. At times during the summer this force is said to have decreased to about 40 men. Development work in 1913 consisted in drifting south in the ore zone on the main level, removing the overburden from the outcrop of the ore body, and mining the ore in the bluff pit by the glory hole method. The ore was trammed from the main level to the sorting house, hand sorted, and stored in the ore bunkers. It was loaded on the steamers by an electric belt conveyor. Only assessment work is reported on Knight Island.

UNAKWIK INLET, WELLS BAY, AND GLACIER ISLAND.

Assessment work was performed on copper prospects on Unakwik Inlet, Wells Bay, and Glacier Island. Some short tunnels are reported on copper properties on Siwash Bay.

GOLD LODES AND PLACERS OF THE WILLOW CREEK DISTRICT.

By S. R. CAPPS.

INTRODUCTION.

The term Willow Creek district is commonly used to designate a rather indefinite area in the southwestern portion of the Talkeetna Mountains. The name has gradually come to be applied not only to the basin of Willow Creek, which drains most of the western portion of the area, but also to all the mountainous portion of the basin of Little Susitna River, and it is in this more general sense that the term is used in this report. The area considered lies between latitude 61° 40′ and 61° 52′ and longitude 149° 7′ and 149° 30′. Both topographic and geologic maps of the region have already been published, but these are on a relatively small scale. The base map used for the present investigation will be published on a scale of 1 to 62,500, or approximately 1 mile to 1 inch. This map and a geologic map of the same area are now in preparation and will be published later with a more complete report on the geology and mineral resources of the district.

In 1898 G. H. Eldridge and Robert Muldrow,[1] of the United States Geological Survey, ascended Susitna River and crossed the divide to the head of Nenana River. In 1905 G. C. Martin[2] spent three weeks in a study of the lower Matanuska Valley coal field. His geologic map included a portion of the Little Susitna basin. During the same year W. C. Mendenhall,[3] while attached to a War Department expedition in charge of Capt. F. W. Glenn, had ascended Matanuska River to its head and crossed the broad basin to the northeast as far as Delta River. The next geologic expedition to the Talkeetna Mountains was undertaken in 1906, when T. G. Gerdine and R. H. Sargent carried a reconnaissance survey around this mountain

---

[1] Eldridge, G. H., A reconnaissance in the Sushitna basin and adjacent territory, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 1-29, 1900.

[2] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska, in 1905: U. S. Geol. Survey Bull. 289, 1906.

[3] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 265-340, 1900.

mass, and Sidney Paige and Adolph Knopf[1] mapped the geology of the area surveyed. Their geologic map covered the Willow Creek district, but the small scale of the map and the hasty manner in which the field work was necessarily done imposed sharp limitations upon the amount of detail which could be presented. Paige spent only a few days in the Willow Creek district, but in that time he succeeded in dividing the rocks into the three main groups, which are still recognized. In 1910 F. J. Katz and Theodore Chapin, after having spent the summer in the Matanuska coal field, made a four days' trip into the Willow Creek district. In Katz's report[2] on the geology and mineral resources of the area he described the economic development which had taken place up to that time and made some corrections to the geologic map of Paige and Knopf.

GEOGRAPHY.

SURFACE FEATURES.

The Willow Creek district includes the southwest corner of the Talkeetna Mountains. It is bordered on the south by the rolling, lake-dotted lowland which lies between Knik Arm and the mountains, and on the east by the broad Susitna Valley. The accompanying map (Pl. X) does not extend far enough westward to embrace all the area commonly included in the district, but it shows that portion in which valuable discoveries of minerals have been made. The district is limited on the east and north by the basins of Little Susitna River and Willow Creek and their headward tributaries. The mountains rise to heights of about 4,000 feet at the western edge of the area mapped, but increase in elevation to the east and north, the highest peaks in the district, near the head of Little Susitna River, reaching elevations of almost 6,000 feet. West of a north-south line through the mouth of Craigie Creek the mountain tops are smooth and rounded. East of that line they are generally ragged and contain many narrow ridges and sharp peaks. The valleys in general are widely U-shaped and head in cirques.

Except for the south front of the mountains, Willow Creek drains the western half of the district, flowing nearly due west to empty into Susitna River. Little Susitna River is much the largest stream in the area. Its bed is filled with large bowlders, and although its course in the mountains is only 15 miles long, it drains several small glaciers and before emerging from the mountains has so greatly increased in volume that during the summer season it can be forded with difficulty and only at a few places. In the winter all the streams freeze over and their flow is greatly reduced.

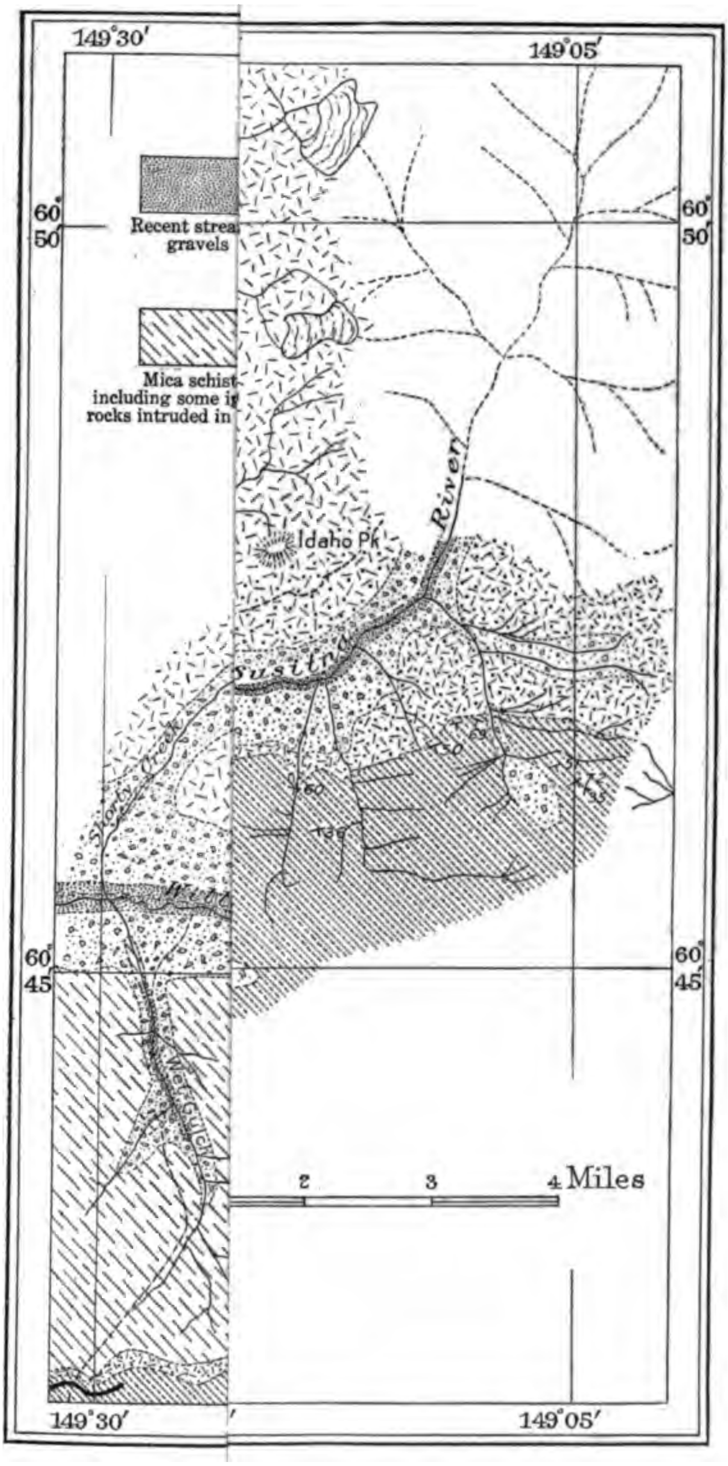
---

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, 1907.

[2] Katz, F. J., A reconnaissance of the Willow Creek gold region: U. S. Geol. Survey Bull. 480, pp. 139-152, 1911.

U. S. GEOLOGICAL SUR

BULLETIN 592 PLATE X



GLACIATION.

The present surface forms of this district are in large measure due to the erosive action of the great glaciers which once occupied all the valleys. Four glaciers still exist in the district (see Pl. X), but these are all small and are only the disappearing remnants of vastly greater ice tongues. At a time geologically not long ago all the larger valleys in the Talkeetna Mountains were occupied by ice tongues which pushed down from the valley heads and extended beyond the mountain borders. The Susitna Valley was then occupied by a great ice field, extending at least as far south as the Forelands, and the Matanuska Valley contributed a great ice stream to this glacier.

ROUTES OF TRAVEL.

The village of Knik, on the northwest shore of Knik Arm, is the center of supplies for the Willow Creek district. Knik is above the head of navigation for ocean-going vessels and can be reached by launch only at high tide. At low tide the tidal flats off the town are bare. The upper part of Cook Inlet is closed to navigation during half of the year on account of the formation of ice. During the open season of 1913 one steamship, plying from Seattle through southeastern Alaska to ports on the Gulf of Alaska and Cook Inlet, made trips at intervals of three weeks to Knik Anchorage, at the mouth of Ship Creek, about 18 miles below Knik. From the anchorage all freight is lightered in scows to Knik, and passengers are transferred by launch. Steamships of another line call weekly at Seldovia, in lower Cook Inlet, and some freight and passengers are brought to Knik from that point in small steamers or launches. In the winter the mail is brought by dog sled overland from Seward to Turnagain Arm, and thence across the divide at the head of Crow Creek and around the head of Knik Arm to Knik, but this service is slow and irregular.

From Knik to the mines of the Willow Creek district two summer trails were formerly in general use. One headed north from Cottonwood, crossed the Bald Mountain ridge to Wet Gulch, and thence followed up Willow Creek to the camps. This trail is still used occasionally. The other route was the old Carle wagon road from Knik, leading in a northeast direction to Little Susitna River below the canyon and thence up that stream and Fishhook Creek. In the spring of 1913 a new wagon road, following in a general way the route of the Carle road, was completed by the Alaska Road Commission to upper Fishhook Creek. This road is well graded, is furnished with good bridges, and is now used for practically all the summer travel to the mines and also for winter travel to the Fishhook and Little Susitna basins. The winter road for sledding to upper Willow Creek heads north from Knik, skirts the west end of Bald Mountain Ridge, and proceeds up Willow Creek.

The summer freight rates by wagon to upper Fishhook Creek are 4 to 5 cents a pound. To Willow Creek supplies must be transported by pack horse from Fishhook Creek, at a considerable additional expense. In winter freight may be sledded to the camps by either the new wagon road or the Willow Creek winter road at about half the cost of summer haulage.

VEGETATION.

All the mines and nearly all the prospects in this district are located above timber line, and the problem of obtaining wood for lumber and for fuel is a serious one. The prospector for his camp purposes uses alder almost exclusively, as it may be obtained at much greater elevations than the more desirable spruce, but even the alder must in many places be brought for a distance of 2 or 3 miles. In Little Susitna Valley some good spruce formerly grew as far north as the mouth of Fishhook Creek, but the demand for this timber has already caused the cutting of practically all the good trees above the canyon, and it is now necessary to haul logs a distance of about 7 miles to the mines on Fishhook Creek. Timber for the mine on Craigie Creek is obtained at a distance of about 4 miles, the upper limit of spruce being at about the mouth of Craigie Creek. Spruce trees 2 feet in diameter at the base are not uncommon and furnish a very fair grade of lumber for mining uses. Spruce is also generally preferred for firewood. Some cottonwood grows in the valleys, and birch is common in the lowlands and grows locally up to elevations of about 1,500 feet. Alders grow profusely in the timber and just above timber line, and patches of them may be found up to elevations of 2,500 feet. Small willow bushes extend even farther up the valleys.

Forage for stock is everywhere abundant from the middle of May until early in September, when the first heavy freeze of autumn usually occurs. The commonest grass is the redtop, which grows in great luxuriance, both in the timber and above it to elevations of about 2,500 feet. After frost comes this grass withers and loses its nutritive value and stock must be fed on grain and hay.

GEOLOGY.

The general distribution of the rock types represented in this district is shown on Plate X. This map differs in some details from the previously published geologic maps of the area, but the main subdivisions shown are the same as those made out by Paige and by Katz. No determinable fossils were found during the present investigations, and the age of one of the rock groups is not known, while that of two other groups can be inferred only by comparison with rocks in adjacent areas in which more definite evidence could be obtained.

The oldest rocks of the district lie for the most part between the crest of Bald Mountain Ridge and Willow Creek. These are highly fissile, thoroughly foliated mica schists and are very uniform in appearance throughout their extent. On the north they are cut off by the intrusive quartz diorite; on the south they are in part overlain by gneisses and in part by the Tertiary sediments. The schists are described by Paige and Knopf [1] as garnetiferous mica schists and chlorite-albite schists. They have been intruded by some dikes, which have themselves suffered metamorphism along with the schists. As will be shown later, the schists are probably the source of some of the placer gold of the district, but although they are cut by numerous quartz veins, including some of considerable size, no encouraging gold-lode prospects have been found in the schist area.

The rocks next younger than the schists are the granitic rocks and associated gneisses. A large part of the Talkeetna Mountains is formed by a great intrusive body of granitic texture, which is often spoken of as granite, but most of which is more properly termed quartz diorite. This rock cuts the older schist and is thus younger. Near the southern edge of the quartz diorite mass, especially near Fishhook Creek and eastward to the border of this district, the rock shows a decidedly banded gneissic structure and includes considerable masses of basic crystalline rocks and some large bodies of nearly pure hornblende. In many places the unaltered diorite seems to merge gradually into the gneiss, but east and southeast of Government Peak the gneissic character is particularly well developed; the banding is very pronounced, and it appears likely that some metamorphosed sediments are included in the gneiss. From a study of this locality a suspicion arises that the gneisses are older than the unaltered granitic rocks, but in the present investigation it was not found to be practicable to separate the gneisses from the unaltered quartz diorites, and they have been mapped as a unit. The granitic rocks of the Talkeetna Mountains were assigned by Paige and Knopf[2] to the Middle Jurassic.

The youngest indurated rocks of the district constitute a thick series composed of arkoses, shales, sandstones, and conglomerates. These were deposited upon an old erosion surface and lie upon both the gneisses and the schist. They cover the south slope of Bald Mountain Ridge and form the southeast rim of the portion of the Little Susitna basin included in this investigation. The beds contain abundant fragments of leaves and plants, but none were found that were sufficiently well preserved to be identifiable. In the eastward continuation of this formation, however, Paige and Knopf and Martin and Katz[3] found plant remains which have shown the beds to be of Eocene age.

---

[1] Page, Sidney, and Knopf, Adolph, op. cit., pp. 10-11.

[2] Paige, Sidney, and Knopf, Adolph, op. cit., pp. 14-15.

[3] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

The deposits left by glaciers and streams are largely confined to the valleys. The glacial deposits consist for the most part of clayey materials in which bowlders, gravels, and angular pieces of rock are embedded. In Little Susitna Valley, at the mouth of Fishhook Creek, the valley sides are covered by this material for over 1,000 feet above the river, and bedrock crops out in the valley bottom at only a few places between the canyon and the cirques in which the river and its tributaries head. Lower Willow Creek has also extensive deposits of glacial materials. The present stream gravels are of remarkably small development in this district. The larger streams for most of their length occupy valleys trenched into the glacial material. As a result the streams have been employed since the retreat of the glaciers in deepening rather than widening their valleys, and the stream beds are consequently narrow and are filled with large bowlders. In the area shown on Plate X, Little Susitna River and its tributaries have developed no considerable flood plains, and the gravels occupy too small an area to be shown on a map of this scale. Willow Creek below the mouth of Grubstake Gulch has a gravel flat which in places reaches a width of several hundred feet.

MINERAL RESOURCES.

GENERAL FEATURES.

The mineral resources of the Willow Creek district that have been sufficient to encourage mining and prospecting are the gold-quartz lodes and gold placers. The gold placers as developed in 1906 have been described by Paige and Knopf.[1]

By 1909 reports of the discovery of gold lodes in the district had begun to attract attention, and Brooks[2] published a brief account based on reports of prospectors and others. F. J. Katz and Theodore Chapin were the first members of the United States Geological Survey to study the gold lodes, and the results of their four days' visit to the district were published in 1911.[3] Short accounts of the developments in this mining district in 1911 and 1912 were given by Brooks,[4] who visited the eastern part of the district in 1912.

GOLD PLACERS.

GRUBSTAKE GULCH.

Practically all the placer gold that has been recovered from this district has been mined on Grubstake Gulch and on Willow Creek near the mouth of Grubstake. According to O. G. Herning, the first

---

[1] Paige, Sidney, and Knopf, Adolph, Reconnaissance in the Matanuska and Talkeetna basins, with notes on the placers of the adjacent region: U. S. Geol. Survey Bull. 314, pp. 116-118, 1907; Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, pp. 65-67, 1907.

[2] Brooks, A. H., The mining industry in 1909: U. S. Geol. Survey Bull. 442, pp. 35-36, 1910.

[3] Katz, F. J., A reconnaissance of the Willow Creek gold region: U. S. Geol. Survey Bull. 480, pp. 139-152, 1911.

[4] Brooks, A. H., The mining industry in 1911: U. S. Geol. Survey Bull. 520, pp. 28-29, 1911; The mining industry in 1912: U. S. Geol. Survey Bull. 542, p. 39, 19

two claims were staked in 1897 by M. J. Morris and L. H. Herndon on Willow Creek at the mouth of Grubstake. In 1899 A. Gilbert staked two claims on lower Grubstake Gulch. In 1900 the Klondike & Boston Co. bought up the claims on Grubstake Gulch and a number on Willow Creek and attempted to operate them for several years. Over 6,000 feet of steel pipe, ranging from 9 to 24 inches in diameter, was placed on the ground, and hydraulic methods were used. The most productive years for this company were 1904 and 1905. The company later became involved in financial difficulties and failed, and in 1908 its ground was relocated by O. G. Herning, who now holds 33 claims on Grubstake and Willow creeks.

Grubstake Gulch, which enters Willow Creek from the southeast, is a hanging valley, glacial erosion having lowered the Willow Creek valley below the level of this tributary. A lateral moraine of the Willow Creek glacier was built across the mouth of Grubstake Gulch, and the stream has now cut through this material and developed a steep, narrow canyon in bedrock beneath it. From the forks of the stream to the canyon, a distance of about half a mile, the stream falls about 200 feet. Through the canyon it drops about 150 feet in a short distance. Below the canyon an alluvial fan has been built out upon the Willow Creek flat, and the stream is now somewhat intrenched into this fan.

The placer ground that has been worked includes part of the bars of Willow Creek below the mouth of Grubstake Gulch, a portion of the Grubstake alluvial fan, the bed of the canyon, and the bars of Grubstake Gulch for some distance above the canyon. The bedrock is mica schist, and the schistosity strikes across the creek and dips at moderately steep angles, thus affording a rough bedrock surface admirably adapted to retain placer gold. The schist is cut in all directions by tiny stringers of quartz, and quartz veins reaching a width of 3 or 4 feet were seen at several places within the schist area.

The first placer production was made in 1898, the gold being recovered from the claims on Willow Creek at the mouth of Grubstake Gulch. It is reported that about $4,000 was taken out. In 1899 about $3,000 was recovered above the canyon on Grubstake Gulch and a small production was made from Willow Creek. During the next four years little active mining was done, but in 1904 and 1905, when the hydraulic plant had been installed, the production reached its maximum. For the last few years mining has been carried on in a desultory fashion and the production has been small. From what could be learned at the time of visit, the largest area of ground mined lies immediately above the canyon, where throughout the length of one claim ground averaging about 200 feet wide has been worked out. The gravels averaged from 2½ to 9 feet in depth, and on the lower half of the claim the gold was recovered from the surface of a bed of clay about 1 foot above bedrock, while on the upper half of the claim the gold lay on the steeply dipping schist bedrock. About 1,200 feet of sluice boxes, 27 inches wide and 30 inches deep, built on 1 and 1½ inch lumber, with 3-inch square frames, were set on a grade of 6 inches to the box length, the average grade of the bedrock. Water for hydraulic sluicing is brought from a dam at the forks of the creek through a ditch and steel pipe. The pipe is 24 inches in diameter at the intake but is reduced to 9 inches at the giant, and 3 and 4 inch nozzles are used. The head of water decreased as mining progressed upstream but was 180 feet at a distance of three-fourths of a mile below the dam. It is reported that the creek bed has been worked as far upstream as the dam. The gold is fairly coarse and the largest nugget had a value of $14; a number of $5 nuggets were found and pieces worth 50 cents to $1 were numerous. The gold is said to assay about $16.60 an ounce.

At the time of visit, late in August, 1913, assessment work on these claims had just begun. A giant was set about 1,300 feet above the canyon, and a cut was started to prospect the thick deposit of gravels on the east side of the creek. The gravels were there from 8 to 15 feet deep, thickening to the east, as the bedrock surface seems to dip in that direction. Few large bowlders were encountered, and scarcely any rocks were uncovered which two men could not handle. The rocks were for the most part flat, somewhat rounded slabs of schist which did not move freely before the giant, and it was frequently necessary to remove them by hand, the larger ones being first broken with a hammer. Boxes 20 inches wide were in use, and two men were mining. It is reported that a good pay streak was discovered east of the present channel of the creek. The total placer production from Grubstake and Willow creeks is said to have been about $25,000.

The task of determining the bedrock source from which the Grubstake Creek placers have been derived presents some difficulties. Veins rich in free gold cut the quartz diorite on Craigie and upper Willow creeks, and at once suggest themselves as an adequate source for the placer gold along Willow Creek. Upper Grubstake Gulch, however, lies entirely within an area of mica schist, and the richest placers are localized in this basin. It is therefore apparent that the placer gold above the Grubstake Canyon must have come from the schists, probably from the veins and veinlets of quartz which are known to carry some gold. Below the mouth of Grubstake Gulch some gold from this gulch is unquestionably included in the gravels of Willow Creek. Placer prospects have been found on Willow Creek above Grubstake Gulch, and their gold was probably derived in part from veins both in the quartz diorite and in the schist. The absence of placers immediately below the outcroppings of the rich gold-quartz veins in the quartz diorite is to be explained by the severe erosion of glacial ice, which removed any accumulation of gravel and the included gold and incorporated it in the glacial materials deposited farther downstream. The present placers are the result of postglacial concentration of gold from the glacial deposits and from the postglacial erosion of bedrock.

WILLOW CREEK.

Prospecting has been carried on at various places along Willow Creek since the first placer discoveries in 1897, but so far the only ground mined on this stream has been that just below the mouth of Grubstake Gulch, already mentioned. The Alaska Hoosier Co. holds 32 claims on Willow Creek below the mouth of Wet Gulch, extending 2 miles downstream, but only assessment work has been done on them. Some years ago a ditch was built from Wet Gulch down the south side of Willow Creek valley for the purpose of hydraulicking some terrace gravels, but no considerable amount of mining was done. The ground has been prospected by pits and by means of a spring-pole drill. Holes have been sunk to a depth of 22 feet, but in the valley floor none have reached bedrock.

FISHHOOK CREEK.

In 1906 some prospecting for placer ground was done on lower Fishhook Creek. Encouraging prospects could be found in many places, and the creek was diverted into Little Susitna River. A 12-foot pit sunk into the channel showed fair values but no ground sufficiently rich to pay. The best prospects were found in the creek bed and the values decreased with depth. Bedrock was not reached. A 12-cent nugget was the largest found, and all the gold was fairly coarse, but large bowlders were so abundant that mining costs would be prohibitive. The placer gold along Fishhook Creek and Little Susitna River is doubtless a postglacial concentration of gold scattered through the morainal deposits, but the large number of great bowlders along these streams make it improbable that placer mining on them would pay.

GOLD LODES.

GENERAL CONDITIONS OF OCCURRENCE.

The principal gold-lode mines and prospects of this district are described in the following pages, but a statement of the general conditions under which the lodes occur seems desirable. All the producing mines and the more promising prospects lie in the area of quartz diorite bordered on the south by Willow Creek, the east-west portion of Fishhook Creek, and upper Little Susitna River. Most of them are included in an area 6 miles long from east to west and 5 miles wide from north to south. Within the narrow limits of this productive area the quartz diorite is for the most part massive and unaltered, though a few prospects along the southern edge lie within a somewhat gneissic phase of the granitic intrusive. Without exception the gold-bearing lodes are quartz veins cutting the quartz diorite. In many places they are banded, and most of them contain some clayey gouge along one or both walls, showing that the period of vein filling was accompanied by movement along the fractures. Although the banding shows that the vein filling was continued throughout a considerable period of time, evidence of only one general period of vein filling has so far been obtained. The veins, while showing considerable variation in strike and dip, for the most part belong to a set which strike in a general northwesterly direction and dip from a few degrees to 45° SW. In places two or three veins in the same mountain are found to be parallel to one another and also parallel to a prominent set of joints. Almost every well-defined vein that was studied is paralleled by a strong set of joints. It appears, therefore, that the gold quartz veins are fillings of joint cracks. The fact that certain joints of a set have a quartz filling while other equally prominent joints of the same set contain no vein material indicates that only a part of the joints had been formed by the end of the period of vein deposition and that after the circulation of the mineralized quartz-bearing solutions had ceased other joints parallel to the earlier ones were formed.

The veins of the district are practically all fillings of fractures parallel to the jointing, with well-defined, generally regular walls. The quartz usually breaks free from the walls, from which it is commonly found to be separated by clayey gouge. Some veins show brecciated wall rock cemented by quartz, and horses of country rock surrounded by quartz are not uncommon. The surface croppings of one vein indicate that it is continuous horizontally for about 1,500 feet, and other veins, while not so well exposed, will probably be proved to be at least equally continuous. Underground workings are not yet extensive, but one adit tunnel 386 feet long and another 240 feet long have been driven on fairly continuous veins. The veins vary in thickness from place to place and are characterized by pinches and swells. The quartz is white to bluish gray in color and in many places is banded. Near the surface it is usually oxidized, and the visible minerals accompanying it consist chiefly of native gold and limonite. The oxidized ore is commonly full of cavities formed by the leaching out of sulphides. A short distance below the croppings the ore is unoxidized, and sulphides, particularly pyrite, are common. The gold occurs for the most part as free gold in the quartz, but some gold is entangled in the pyrite. Reports of tellurides have been common, and chemical tests of a number of these ores were made. The particles of tellurides in the [illegible] examined were too small to enable the identification of the mine[illegible]des free gold, the following metallic minerals were identified in the district: Pyrite, arsenopyrite, stibnite, chalcopyrite, bornite, chalcocite (?), malachite, galena, molybdenite, cinnabar, and an unidentified telluride. Details of the several veins are given in the following descriptions of the mines and prospects.

MINE OF ALASKA FREE GOLD MINING CO.

The property of the Alaska Free Gold Mining Co. comprises a group of 13 claims lying on the bold mountain ridge which forms the west wall of the Fishhook Creek valley, north of Hatcher Creek. The claims, covering practically all of the east slope of this ridge and including a part of the west slope, near the summit, have been surveyed for patent, as has also a mill site on Fishhook Creek. The company is organized as a stock company but is now operated under an eight-year lease, beginning in 1912. It was on this property that the first discovery of gold quartz in this district was made, the first claim being staked on September 16, 1906. Since that time development work and mining have been carried on each summer. The improvements at the mine consisted at the time of visit of a mill and blacksmith shop on Fishhook Creek, and adjoining bunk and mess tents to accommodate about 30 men; two main tramways and a branch tram connecting the mill with the ore bodies; two inclined tunnels 50 and 85 feet long on the lower vein, connected by drifts and stopes; a 95-foot adit tunnel on the main upper vein, and numerous short tunnels, open cuts, and pits on the vein croppings on the several claims.

The mill, operated by a Pelton wheel working under a 35-foot head of water, is a Lane slow-speed Chilean mill, designed to turn about 7 revolutions a minute, and to crush to 40 to 60 mesh. It was first put into service about August 1, 1912. Its maximum capacity is about 25 tons in 24 hours, the ore being passed through a rock crusher before entering the mill. The water supply is adequate to operate the mill only during a portion of the open season, and a 16-horsepower gasoline engine has been installed to furnish power during periods of low water. From the mill the crushed ore passes to two sets of amalgamating tables and thence is fed to two Bartlett concentrating tables, operated by a small overshot water wheel. From 1 to 2 per cent of the ore crushed is saved as concentrates. From 70 to 75 per cent of the gold saved is said to be amalgamated in the mill, and the remainder is caught on the plates. At present the concentrates and tailings are not treated but are being stored until a cyanide plant is installed.

Two principal ore bodies have been opened on this property, ough there are openings at a number of places on veins which may not be continuations of these two main veins. The lower of the two has been opened at the head of the south tramway, at an elevation of about 4,300 feet, 900 feet above the mill. It will here be called the Homestake vein, as the principal workings are near the boundary between the claims known as the South Homestake and North Homestake. This vein crops out at about the same elevation and has the same general strike and dip as the Granite Mountain vein of the Alaska Gold Quartz Mining Co., 1,500 feet to the north, and it appears likely that the vein is more or less continuous between these two properties, although it has not yet been directly traced throughout the intervening distance. At the head of the tramway the vein is opened by two inclined tunnels 50 feet apart, one 85 and the other 50 feet long, connected at 50 feet from the surface by a drift. The ore was brought to the surface in a car tram operated by a windlass. Most of the ground between these tunnels is stoped out for 25 feet below the outcrop. The average strike of the vein is here about N. 13° W., and the dip varies from 30° at the surface to 42° at the tunnel face. The vein filling, lying between quartz diorite walls, was from 6 to 24 inches thick and was associated with some gouge and clayey matter. The vein cropping has been exposed for several hundred feet along the surface. To the north it has been traced as far as the north tramway, and to the south it was followed to the edge of a large talus slide. It is said that to the south it pinches out to a thin edge. A large part of the ore milled at this mine in 1912 is said to have been taken from this vein.

The upper main vein on this property, known as the Skyscraper vein, is opened by a tunnel at an elevation of about 4,600 feet on the north slope of Skyscraper Mountain, near its top. These workings are at the head of an 850-foot branch aerial tram, which runs in a northeast direction and discharges at the head of the main north tram, 2,500 feet from the mill. At the time of visit the adit tunnel, which is equipped with a car tram, was 95 feet long, and work was in progress in the breast. At 40 feet from the portal a raise reaches the surface 36 feet above. As opened by this tunnel, the vein ranges in thickness from 18 inches to 8 feet of solid quartz, associated with some gouge. The vein matter is generally free from the walls, and there is evidence that considerable movement has taken place along the walls. The vein pinches and swells, but the strike and dip are fairly uniform. The average strike is about N. 15° W. and the dip 40°-45° W.

A short distance southeast of the tunnel and above it, on the outcrop of the same vein, is a large open cut which supplied about two-thirds of the ore milled in 1913. In this cut the vein is split into two parts by a large horse of diorite measuring 15 feet in greatest thickness. Above the horse there is said to be about 5 feet of milling ore, and below it from 4 to 10 feet of ore. At a point 380 feet southeast of the tunnel mouth is another open cut on the same vein, showing about 9 inches of quartz. The tunnel is being driven for this point.

The quartz of the Skyscraper vein is in general massive, though locally showing a banded structure. In the open cuts it is rusty from iron oxide and full of cavities formed by the leaching out of the sulphides. A short distance from the surface, however, oxidation of the sulphides has taken place only along cracks in the vein, and the massive quartz has a light to dark blue-gray color. It contains, besides native gold, rather abundant pale pyrite and some chalcopyrite. A little galena is reported. The native gold occurs both as particles in the quartz not immediately associated with pyrite and as intergrowths in the pyrite, as can be seen from the delicate crystals projecting into the cubical cavities from which the pyrite has been leached. The production in 1913 was diminished by the scant supply of water, as the mill was operated to capacity for only a part of the short open season.

A third vein of proved economic importance crops out on the Eldorado claim, about 3,000 feet south of Skyscraper Mountain. This vein has been developed by several large open cuts and by a 30-foot inclined tunnel, at an elevation of about 4,270 feet. The country rock is a much-decayed quartz diorite. The vein ranges in thickness from 1 inch to 18 inches of solid quartz, associated with some clayey gouge. It strikes N. 24° W. and dips about 36° W. and is therefore nearly parallel with the other veins on Skyscraper and Granite mountains to the north. The quartz is oxidized and rusty, as is also the country rock, even at a distance of 30 feet from the surface. It is reported that in 1912 about 100 tons of ore from this vein was dragged down a trail to a point from which it could be trammed to the mill.

A number of other open cuts and short tunnels on this property expose quartz veins of varying size and gold content, but none of them has yielded ore in commercial quantity.

In 1911 a few tons of ore from this property was milled in the mill of the Alaska Gold Quartz Mining Co., and this was the first gold produced from this mine. In the spring of 1912 the Chilean mill was installed, and about 525 tons of ore was milled that summer. In 1913 the mill was run to as great capacity as the water supply permitted and about 25 men were employed continuously during the working season.

MINE OF ALASKA GOLD QUARTZ MINING CO.

The property of the Alaska Gold Quartz Mining Co. lies for the most part in the upper portion of the valley of Fishhook Creek, on the east slope of Granite Mountain. It comprises a group of five claims and a mill site, all of which have been surveyed for patent. The claims form an irregular tier extending from Fishhook Creek up the mountain to the west and include a portion of the divide between Fishhook Creek and Willow Creek. The claims were located in 1907, and development work and mining have been carried on each year since. The improvements consist of a 4-stamp mill, located on Fishhook Creek, two aerial tramways extending from the ore bodies to the mill, a group of tents in the valley, a blacksmith shop and car tram at the main tunnel, several hundred feet of adit tunnels and stopes, and a number of open cuts on the croppings of the ore bodies. The mill is operated by a small Pelton wheel, which works under a 120-foot head and develops about 15 horsepower. The mill equipment first installed consisted of a prospecting mill of three 500-pound stamps, manufactured by the Mine & Smelter Supply Co. Later a 1,250-pound Neissen stamp was added. The capacity of the four stamps was about 8¼ tons in 24 hours, with the small stamps dropping 98 times a minute and the large stamp 90 times. The ore is crushed to 40 mesh and passes from the stamps over amalgamating plates and thence over a Wilfley concentrating table. The concentrates are said to bear a proportion of about 1.80 in the more or less oxidized portions of the vein and of about 1.40 in the unoxidized ore about 400 feet from the surface. The concentrates and tailings have been saved for future treatment, but up to the present time all the values recovered have been in free gold by amalgamation in the mortars and on the plates. When the mill is running to capacity the plates are cleaned every 24 hours and the mortars once a week. Two 2-bucket aerial trams equipped with ⅝-inch cable lead from the ore bodies to the mill. The lower of the two, heading at the mouth of the main tunnel, is about 1,700 feet long and is supported by one tower near the mill. The other tram is 2,460 feet long in a single span and has a vertical distance of about 1,100 feet between the ends.

Two principal ore bodies crop out on this property. The main tunnel on the lower or Granite Mountain vein, which has furnished most of the production, and which crops out on the walls of a small cirque, is at an elevation of 4,150 feet, or 500 feet above the mill. The upper or Independent vein lies high on the mountain, 620 feet vertically above the Granite Mountain vein, and has so far been prospected only by shallow openings. The country rock is everywhere the quartz diorite which forms all the northern part of this district.

The Granite Mountain vein is developed by a main adit tunnel 386 feet long, another adit tunnel 80 feet long, several short tunnels and open cuts, and several stopes, some of which connect the two larger tunnels with each other and with the surface. In general the vein strikes N. 14°–20° W., the strike varying somewhat in different parts of the vein. The dip also is rather irregular, varying from 10° to 42° SW., but averages about 20° SW. At the portal of the main tunnel the vein cropping shows only 1 or 2 inches of quartz, but in the tunnel the quartz vein matter varies in thickness from 2 inches to 4 feet, rarely pinching to less than 8 inches and averaging about 22 inches. The vein pinches and swells abruptly and contains some horses of country rock but is continuous throughout the tunnel. In one place a dip fault has displaced the vein about 4 feet.

The vein walls are distinct and smooth, are generally slickensided, and are in most places separated from the vein by a layer of gouge matter of varying thickness. The quartz is characteristically massive, though it is banded in places. It is of a light-gray to dark blue-gray color and where unoxidized shows, besides native gold, rather abundant pale pyrite, some chalcopyrite, and specks of some unidentified dark sulphide. The vein matter has been somewhat shattered and slickensided. Very near the surface the ore is rusty and most of the sulphides have been removed by oxidation. Farther underground iron oxide occurs along certain cracks in the ore, but most of the sulphides are unaltered a short distance from the surface. The better ore from this vein occurs in chutes, four of which were encountered in a distance of 386 feet along the strike of the vein.

The upper vein on this property is known as the Independence vein and is connected with the mill by an aerial tram at an elevation of 4,770 feet, 1,120 feet above the mill. The vein strikes N. 12° W., or approximately parallel to the Granite Mountain vein, and its average dip is about 42° W. Although its southward continuation has not been directly proved, it is without much doubt on the same plane as the main upper vein on the property of the Alaska Free Gold Mining Co., and future developments are likely to show that the vein is continuous between these two properties. The developments at the time of visit consisted of an open cut about 100 feet long and a 15-foot tunnel at the head of the tramway, and other open cuts on the vein both to the north and to the south. The vein, as seen at the several openings, is from 2 inches to 2 feet in thickness, averaging about 12 inches, and is accompanied by considerable sheared matter and gouge. The walls consist of blue-gray diorite, somewhat sheared near the vein. The vein near the tramway is forked, a portion of it cropping out about 30 feet below the tunnel. The vein quartz is less massive than that of the Granite Mountain vein, is generally banded, and consists of interlocking crystals of quartz containing free gold, a little pyrite, and small quantities of some other sulphides. Only a small quantity of ore from this vein had been mined up to the fall of 1913, but it was planned to build a cabin near the outcrop and run a tunnel on the vein that fall. It was reported that on September 3, 1913, this tunnel had been driven 34 feet on the vein, and that approximately 4 feet of good ore showed in the tunnel face.

In 1913 difficulties were encountered in keeping the mill in operation, numerous breakdowns causing a serious curtailment in the output, although enough ore was available to supply the mill, and the water supply was sufficient to furnish power throughout most of the summer. Plans were being made to install a new mill that winter.

MINE OF GOLD BULLION MINING CO.

The Gold Bullion Mining Co.'s property is situated on the southeast wall of the Craigie Creek valley, about 4 miles above the mouth of the creek. The first claims were staked in 1907 by William Bartholf, and the group now includes five full claims and a fractional claim, which have been surveyed for patent. The improvements consist of a group of buildings and a 7-stamp mill located in the valley, two branch aerial trams supplying a main aerial tram to the mill, a short aerial tram and a car tram at the upper workings, which are provided with a stone mess house, blacksmith shop, and bunk tents, several hundred feet of tunnels and stopes, and numerous open cuts and strippings. The main workings are connected with one another and with the mill by trails. Power for the mill is provided by a 12-inch Pelton wheel operated under a 28-foot head, about 25 horsepower being developed. Some power is also needed to run the main tramway. Two 1,000-pound Hendy stamps were installed in 1909, and in 1911 five 1,000-pound Halladie stamps were added. The ore is first passed through a coarse crusher and then fed to the stamps, which are regulated to drop from 100 to 103 times a minute, crush to 40 mesh, and discharge over two sets of amalgamating plates and thence over a Wilfley concentrator. The capacity of the stamps is about 21 tons of ore in three shifts of eight hours each, and the ore concentrates in about the ratio of 1 to 200. In 1909 the two stamps then installed were supplied with ore brought to the mill on pack horses, but the next year a cable tram was installed. The main tramway which now supplies the mill is a 2-bucket aerial tram, equipped with ⅞-inch cable, and is 3,253 feet long, with a rise of 850 feet. It is supported on a number of towers. The buckets have a capacity of 400 pounds, and the tram is of sufficient capacity to keep the mill well supplied with ore. At the head of the main tram there are ore bunkers supplied by two trams, one about 1,600 feet long from tunnel No. 5, and one 1,450 feet long from tunnel No. 2, each equipped with ¾-inch cable and two buckets. These trams both consist of single spans unsupported by towers. From the mouth of tunnel No. 2 a car tram 945 feet long follows the mountain slope to the northeast and is fed by an aerial tram 635 feet long, which heads at Discovery, on the Gold Dust claim.

The vein croppings on the Gold Bullion property occur near the summit of the ridge which separates the upper valleys of Craigie and

Willow creeks. The workings are at elevations of 4,400 to 4,600 feet, and the mill in the valley bottom is at 3,050 feet, or about 1,500 feet below the ore bodies. The discovery of the veins on this property in the high, craggy ridge top is no doubt due to the good exposures of bedrock which occur there. Below the workings most of the bedrock is so concealed beneath a covering of talus and of glacial deposits that prospecting is difficult.

The ore milled in 1909, which yielded the first gold recovered from this property, is said to have been obtained from the talus and from open cuts on the Gold Dust claim, the place of the original discovery. During the years from 1910 to 1912 the ore milled was taken from tunnels Nos. 3, 4, and 5, No. 5 furnishing most of the production. In 1913 the production was obtained largely from open cuts and from tunnel No. 1 on the Gold Dust claim, from the same locality that was first mined.

At the time of visit access could be had to the many open cuts on the property, and to adit tunnels Nos. 1, 2, and 4. Tunnels Nos. 3 and 5 had caved in at the portals and were inaccessible. Active mining was being carried on in open cuts near tunnel No. 1 and in that tunnel itself, which was 30 feet long, and a prospecting tunnel, No. 2, was being driven along the vein and had penetrated several hundred feet into the mountain. Between these two tunnels numerous open cuts and strippings have exposed the vein, and although the exposures are not continuous, it is most likely that both tunnels, and No. 3 as well, are all on the same vein. Tunnels Nos. 4 and 5, while somewhat higher on the mountain than the projected dip of the vein from No. 2 would indicate, are in ground that has been somewhat faulted and disturbed, and it is not improbable that the veins on which they were driven are parts of the same ore body exposed in the other workings. The vein may, however, be somewhat displaced by faulting, or it may even prove to be a distinct ore body.

At tunnel No. 1 the vein strikes about N. 28° E. and dips 15° W. Open cuts show its continuation on the opposite side of the ridge to the south. At the time of visit the tunnel was 30 feet long, but it is reported that by October 15, 1913, it had been driven to a length of 184 feet. As exposed in the tunnel the vein is from 3 to 7 feet thick and is composed largely of white or bluish quartz, rusty along the fractures. Sheared matter and gouge occur both above and below the vein, which cuts the quartz diorite. Visible particles of free gold could be seen in many pieces of the ore, as well as small amounts of pyrite and chalcopyrite. Particles of some other finely disseminated sulphides are also present, and copper carbonate stains are common. Although both the country rock and the vein are much fractured, many of the fractures being filled with ice, the ore at even so short a distance as 30 feet from the portal of the tunnel is not greatly oxidized, except along fractures, and many of the sulphides are unaltered. The open cuts at this place have disclosed a large amount of oxidized and broken vein quartz mixed with the surface detritus, and this loose surface material supplied a considerable proportion of the ore milled in 1913. The surface portion of the veins seems to yield somewhat higher returns than the fresher material from the underground workings, probably as a result of the freeing of some gold by the oxidation of the sulphides. At present the only gold recovered is free gold, obtained by amalgamation. Adit tunnel No. 2 has yielded a little milling ore, but most of it has been driven in the hope of opening an ore body. The tunnel is on the Golden Wonder claim, and the vein, which ranges in thickness from 5 feet to the vanishing point and averages about 2 feet, strikes approximately N. 30° E. and dips about 14° W. In the breast of the tunnel the vein had thinned out to a small stringer. It is reported that on October 15, 1913, the tunnel had been driven to a length of 240 feet and the vein had widened out, giving a width of 3½ feet of paying ore.

Tunnel No. 3, about 400 feet west of No. 2 and presumably on the same vein, is now caved in but is reported to have yielded considerable good ore.

Adit tunnel No. 4 is said to be 300 feet long, and the vein ranges from 2 feet in thickness down to a small stringer. No work was being done on this tunnel in 1913.

Tunnel No. 5, which is now caved in and abandoned, furnished most of the ore milled in 1912. The vein is said to have had a maximum thickness of 14 feet, though averaging much less than that. In 1913 a small quantity of ore was recovered from the outcroppings of the vein near the site of the old tunnel entrance.

In the mill practice at this mine the only metal which has been recovered so far has been the free gold caught by amalgamation in the stamp mortar boxes and on the plates. In 1913, during the time when the mill was running 24 hours a day, the plates were cleaned up at the end of each 8-hour shift and the mortars were cleaned every 48 hours. The concentrates from the Wilfley table have been stored separately and all the tailings have been impounded. About 4,000 tons of tailings are now stored ready for treatment, and plans are being made to install a 30-ton cyanide plant in 1914. In 1913 the mill was run three 8-hour shifts a day, and two shifts were worked in the mines. About 30 men were employed continuously during the summer. In the fall the number of stamps in operation was reduced as the water supply diminished. The 5-stamp mill ran during the season for a total of 59 days, and the 2-stamp mill for 72 days. It was planned to continue underground mining all winter.

MABEL MINE.

The Mabel mine is situated on the west wall of the Little Susitna Valley, 3 miles above the mouth of Fishhook Creek. The workings, at an elevation of 3,700 feet, are in a small gulch tributary to Little Susitna River, and the camp is near the same gulch, about 800 feet below the workings. The property comprises a block of 12 claims staked to cover the known outcroppings of the veins. The claims were staked in the fall of 1911, and a moderate amount of development work has been done since that time. In 1912 an open cut was made on the vein and an inclined tunnel driven down the vein for some distance, but water in this tunnel became bothersome and it was decided to drive an adit tunnel below to crosscut the vein. At the time of visit the open cut and inclined tunnel were badly caved and little could be seen, but in places a slip zone, said to be on the vein and containing about 8 inches of gouge and a little quartz, was observed to cut through the quartz diorite country rock. This zone strikes in a general northerly direction and dips about 45° W. The vein, as opened in the inclined tunnel, is said to range from 2 to 18 inches in thickness. Ore taken from it showed a decided banding of white quartz with visible interlocking crystals and dark blue-gray fine-grained quartz. Several tons of quartz were obtained from the workings in 1912, and 6 tons was shipped to Tacoma for smelting.

In 1913 an adit tunnel was started 20 feet below the earlier workings and when visited had been driven 51 feet under cover. It was expected that the vein would be struck within a short distance. Near the mouth of this adit tunnel is another quartz vein cutting quartz diorite. This vein strikes N. 52° W. and dips 55° SW. It is from 6 to 8 inches thick and consists of massive rusty and oxidized quartz which breaks free from the walls and contains some horses of country rock. The sulphides have for the most part been removed by oxidation in this surficial portion of the vein, though some pyrite remains. It is probable that the amount of sulphides will be found to increase at no great distance from the surface. Visible free gold could be seen in many specimens of the quartz, and small pieces mortared and panned gave many colors of free gold.

A good horse trail has been built from the wagon road to the camp and also to the tunnel mouth. Plans were under consideration to construct an aerial tram from the tunnel to a mill site on Little Susitna River in 1914.

ARCH PROSPECT.

The Arch prospect is situated on the south side of Archangel Creek, about 1½ miles above the mouth of that stream, at an elevation of 3,200 feet, 550 feet above the valley bottom. This property, which consists of a group of four claims called the Arch group, has been generally known as the Fern, Taulman & Goodall prospect but changed hands in the summer of 1913. At the time of visit there was no one on the ground, and the main tunnel was caved and partly filled with water, so that little could be seen. A good stone house and blacksmith shop have been built near the prospect, and a good trail extends from the cabin to the main trail in Little Susitna Valley.

The vein, which cuts quartz diorite, has been developed by a number of open cuts and by an inclined tunnel said to be 80 feet long. The tunnel follows down the vein, which in the somewhat disturbed ground through which the outer portion of the tunnel is driven strikes N. 33° E. and dips 21° NW. In the accessible portion of the tunnel the vein was from 10 to 40 inches wide and the filling was mostly a clayey gouge, with little quartz. It is said that farther in the tunnel a maximum of 12 inches of quartz was obtained. The quartz, as seen on the dump, is banded and consists of interlocking quartz crystals surrounding pieces of altered country rock. Sulphides are present only in small amounts.

Under the new management a new adit tunnel to crosscut the vein 180 feet below the old incline was started in the fall of 1913, and two other drifts are reported to have cut the vein, showing from 12 to 20 inches of gold-bearing quartz. It is planned to install two small Lane mills on Archangel Creek in the summer of 1914, water for power being obtained from the tributary which joins the creek from the south near the mill site.

BARTHOLF-ISAACS PROSPECT.

The four claims of the Bartholf-Isaacs prospect are located in the upper basin of Archangel Creek, about a quarter of a mile above its mouth. They were staked in June, 1912, and only assessment work has been done on them. No one was working on these claims at the time the area was surveyed, and they were not visited by the writer. It is reported that five open cuts have been made which show the vein at its greatest size to cut quartz diorite and to contain 2 feet of quartz and 5 feet of gangue.

PROSPECT OF BROOKLYN DEVELOPMENT CO.

The Brooklyn Development Co.'s property consists of five mining claims and a mill site in the basin at the head of Willow Creek. The claims are said to have been located in 1909, and have been surveyed for patent. The developments consist of two buildings in the valley bottom, a large number of open cuts and trenches, and two adit tunnels, 40 and 180 feet long. The upper adit tunnel, at an elevation of 4,400 feet, is driven through quartz diorite. It was started on a quartz vein 6 to 8 inches thick, striking approximately east and dipping 15° S. A short distance from the entrance the vein was cut off by a fault, and the remaining portion of the adit shows no continuous vein, although the diorite is seamed and fractured and a little clayey material appears along some of the fractures. The quartz from the vein near the entrance is rusty and much fractured and shows some banding. The vein is now for the most part concealed, but the few bits of quartz obtainable showed little mineralization. Nothing was learned of the gold content of this vein.

The main adit, about 60 feet below the shorter one, is a somewhat crooked tunnel 180 feet long, and there are three 10-foot crosscuts extending from it to the south. On the surface there is said to have been a vein cropping of about 7 inches of quartz, but the tunnel follows a seam in the quartz diorite, containing some clayey material but almost no quartz. In the breast of the tunnel there are a few small quartz stringers, and one crosscut shows 2 inches of clayey gouge with a little quartz. No ore body has been developed in this tunnel. The numerous open cuts and trenches on the property are caved in, and little could be seen in them.

A stamp mill for this property was purchased several years ago and freighted in to a point on Willow Creek 7 miles below the cabins but never delivered at the site upon which it was to be installed.

GRIMES PROSPECT.

The Grimes prospect comprises a group of eight claims, known as the Dolores group, situated on the north side of the ridge which divides the Fishhook Creek drainage basin from that of Archangel Creek. The ground was staked in 1912. The developments consist of a number of open cuts distributed throughout a vertical range of 300 feet and supposed to be on the same vein. The line of cuts strikes a little east of north, but little could be seen of the vein in place, as the sides of the cuts have caved in. The lowest cut, at an elevation of about 3,600 feet, shows on the dump pieces of quartz from a vein at least 10 inches thick. The quartz shows some banding and contains bits of altered country rock but is for the most part rather massive white quartz, somewhat oxidized. The country rock is quartz diorite, cut by a prominent set of joints striking N. 15° W. and dipping 43° SW., and the vein is probably a filling of a joint of this set. Another cut, at an elevation of about 3,200 feet, has on the dump considerable rusty banded quartz stained with malachite. The vein is evidently at least 6 inches thick. Another open cut above the two already described is said to expose 14 inches of quartz which carries sulphides and free gold.

HATCHER PROSPECT.

The Hatcher prospect comprises three claims known as the Little Gem group, in the upper basin of Archangel Creek, about a mile above the mouth. The claims were staked in August, 1913, and were not visited by the Survey party, as no development work had been done at the time that portion of the area was mapped. It was reported in September that an adit tunnel 15 feet long had been driven on this property, disclosing a quartz vein from 1 to 10 inches thick, cutting the quartz diorite country rock. This vein is said to be traceable for 1,500 feet along the surface and to carry considerable gold. A large specimen from this vein showed abundant free gold in coarse specks. It is planned to install an aerial tramway and a 3-stamp prospecting mill on this property in 1914.

McCOY PROSPECT.

The McCoy prospect includes a group of 19 claims on the east slope of the mountain which lies west of the lower Reed Creek valley. The claims were located on June 28, 1913, and prospecting during the year was confined to digging open cuts to uncover the vein croppings. At the time the property was visited no one was working on the claims. About 20 open cuts were examined. None of these are large, and only a part of them reached undisturbed bedrock. Several of the cuts had a small amount of quartz on the dumps, and one showed 4 inches of clayey gouge in place, containing a little quartz. The country rock on this mountain is all coarse quartz diorite, with some inclusions or segregations of a gray sugary porphyritic rock. It is reported that the best showing of quartz on the property is north of the cuts visited. There are said to be three veins, the largest reaching a maximum known thickness of 7 feet. The veins are reported to strike in a northwest direction and to dip to the southwest.

MAMMOTH PROSPECT.

A group of four claims, known as the Mammoth group, is located in the Willow Creek valley on the mountain which lies north of the pass between Fishhook and Willow creeks. The main workings lie at an elevation of 3,800 feet, or 450 feet above Willow Creek. Active development work was carried on during the winter of 1912–13, a 200-foot adit tunnel, with 73 feet of crosscuts and a 12-foot raise, being driven. The vein at the tunnel entrance shows a large body of quartz 28 to 30 feet wide, striking approximately east and dipping 68° N. About 30 feet from the tunnel entrance a fault has cut off the vein abruptly, and the remaining 170 feet of tunnel on this level was driven on a slip zone full of clayey gouge, but the vein was not again encountered. The country rock is a somewhat gneissic quartz diorite which has been broken by slips in several directions. The walls of the slip zone on which the tunnel was driven are well defined, and although they show some rolls, the direction of the zone is fairly constant. The walls are smooth and in many places show slickensides, and the rock has been much altered. In the breast there is about 3 feet of clayey gouge and sheared, altered diorite, with good walls of solid rock on either side. A 35-foot crosscut to the north leaves the main adit 100 feet from the portal, and one or two other short crosscuts have been made, in none of which was the vein encountered. About 70 feet from the portal a 15-foot raise on a slip zone entered a body of quartz, but a 28-foot crosscut from the raise cut through the quartz body, which proved to be an irregular portion of the vein surrounded on all sides by faults. The faulted-off portion of the main vein has not been found in the underground workings.

The quartz is for the most part massive white vitreous quartz, mottled with patches of a bluish-gray color. It shows scattered specks of pyrite and chalcopyrite with stains of copper carbonates. The assays that have been made show the vein to be ore which is of low grade for this district. The vein is, however, the largest seen in the region, and if its underground continuation is established and the tenor holds, there is here the possibility of a mine from which much gold might be recovered.

MINE OF MATANUSKA GOLD MINING CO.

The property of the Matanuska Gold Mining Co. is situated on the north side of a cirque in which Fairangel Creek has its head. At the time of visit there was no one on this ground, on which only assessment work has been done for the last two years, as the property is now involved in litigation. The four claims of this group were staked in 1909, and considerable development work was done in 1910 and 1911. A good trail was built from the Little Susitna Valley to the workings, many open cuts were made, and adit tunnels aggregating over 200 feet in length were driven. The camp, consisting of several tents, is near the creek at an elevation of about 3,500 feet. The country rock in this vicinity is a coarse gray quartz diorite with many inclusions of a gray sugary porphyritic rock. The diorite is cut, near the vein croppings, by small aplite dikes, locally called "quartzite." The dikes are older than the vein fillings, for in places the quartz veins cut the dikes, and cracks in the dikes are quartz filled.

The working nearest camp, at an elevation of 3,680 feet, is a 20-foot tunnel in diorite. No veins show in this tunnel, which was evidently driven to crosscut a vein that crops out on the slope 50 feet above. At the cropping a 22-foot adit shows two quartz veins in the breast, one from 1 to 3 inches thick striking N. 22° W. and dipping 42° NE. and the other from 3 to 8 inches thick striking N. 47° E. and dipping

71° NW. Above the tunnel the smaller vein has been exposed by stripping for a vertical distance of about 50 feet. At a point about 75 feet west of this exposure an adit tunnel, which is said to be 85 feet long, has been driven to intersect the larger of these veins. A cave-in has closed this tunnel about 60 feet from the portal, but it is reported that the position of the vein is believed to be about 10 feet beyond the breast of the tunnel. The tunnel is driven on a slip zone, from 12 to 18 inches wide, which contains much gouge and a little quartz and which strikes N. 44° W. and dips 72° NW., or approximately parallel to the vein in the tunnel. The vein matter, as seen in the tunnels and on the dumps, is from 3 to 12 inches thick and consists of banded white and blue-gray quartz. The quartz contains some visible particles of free gold and considerable sulphides, mostly pyrite. Near the surface it is somewhat rusty and shows small cubical cavities containing iron oxide, the result of the leaching of the pyrite.

At an elevation of about 3,930 feet, or approximately 250 feet above the vein just described, is another quartz vein closely associated with an aplite dike. The vein is younger than the dike, the quartz cutting across the dike and filling fractures in it. An adit tunnel has been driven for 84 feet along the vein, which strikes N. 33° E. and dips 45° W. The vein is distinct on the hanging wall, there being in places 12 to 15 inches of solid quartz. Below this hanging-wall quartz there is a stockwork of reticulated quartz veins inclosing fragments of diorite and containing some gouge. At many places the walls and the ore show slickensides. The same vein is exposed a short distance above the tunnel by strippings and by an open cut. Here the dike and the vein come together. The dike, which along its outcrop varies in thickness from 1 to 6 feet, is at the cut about 6 feet thick and has quartz lying parallel to it both above and below. The vein pinches and swells but in places showed 30 inches of vein matter, mostly quartz, with small inclusions of altered diorite. Some caving has taken place in this cut, and the relations have thereby been partly obscured. The vein walls, the quartz filling, and the diorite fragments inclosed in the quartz all show fine specks of sulphides, mostly pyrite.

Another 24-foot adit tunnel on this property was driven on an aplite dike. The dike rock shows disseminated pyrite.

MILLER PROSPECT.

The Miller prospect is on the east side of Little Susitna River, 1 mile below the mouth of Fishhook Creek and about 60 feet above the river. The developments consist of two cabins on the west side of the river, a footbridge across the river, and a 30-foot adit tunnel driven from the bottom of a steep, narrow gulch. The tunnel follows a thick band of siliceous rock which has been locally called a vein but which proves from study in this section to be an altered igneous rock. The "ore" is white to greenish gray in color and in places contains considerable quantities of sulphides. The so-called "vein" is ill defined in outline and but little of it is exposed. The associated rock is coarsely crystalline and belongs to the gneiss series. Only assessment work has lately been done on this property. Nothing definite was learned of the value of the ore, as assays are said to have given conflicting returns.

MOGUL PROSPECT.

The Mogul prospect comprises two claims situated on a high rock bench in the upper Reed Creek valley, 2½ miles above the mouth of that stream, at an elevation of about 4,000 feet. The claims were staked in September, 1912, and have been developed by three open cuts about 15 feet from one another along the croppings of a quartz vein that cuts quartz diorite. The southernmost cut, about 10 feet long on the bottom, shows about 6 inches of clayey gouge with 2 inches of quartz. The middle cut shows 18 inches of clayey vein matter with 1 to 4 inches of quartz. The north cut shows 4 inches of quartz and gouge above, separated by 18 inches of altered diorite from a lower 12-inch vein of quartz. The vein quartz is very drusy, and small, slender quartz prisms project into the cavities. Much iron oxide is present, and some sulphides. The vein is reported to have given high assays in gold.

RAE PROSPECT.

The Rae prospect consists of four claims called the Jennings group, situated on the divide between Fishhook Creek and Little Susitna River, 1 mile north of the east-west portion of Fishhook Creek. The claims lie in an area of more or less gneissic quartz diorite, which is cut by a considerable fault or shear zone. Two open cuts on the Fishhook Creek side of this property were examined. The larger of these cuts was dug from the bottom of a steep gulch, at an elevation of about 4,000 feet, or 1,100 feet above the valley floor, and extended 15 feet into the mountain side. The country rock is deeply oxidized and decayed gneissic diorite, and the cut was driven on a layer of sticky yellowish clay or gouge from 8 to 18 inches in thickness, striking in a general northeast direction and dipping 43° NW. Some quartz occurs in the clayey material and contains free gold, chalcopyrite, pyrite, galena, and copper carbonates.

A second open cut, 20 feet above the first, shows the same altered country rock, with thin rusty seams. The slight amount of work done on these claims is insufficient to either prove or disprove the presence there of ore bodies of economic importance.

ROSENTHAL PROSPECT.

The Rosenthal prospect comprises the Sun, Moon, Morning Star, and Evening Star claims, all located on the high ridge which borders the Fishhook Creek basin on the northeast. The claims were located in 1907 and have since that time been owned by several different persons. The developments consist of a fair trail from the valley of Fishhook Creek, a crude blacksmith shop, and two adit tunnels. The larger tunnel is on the west side of the ridge, is about 95 feet long, and is driven along a vein which cuts the quartz diorite country rock. The vein consists of white, somewhat banded quartz, strikes N. 40° W., and dips 10° SW. It ranges from 1 to 3 feet in thickness and carries some visible specks of free gold and finely disseminated pyrite. This flat-lying vein is close to the mountain top, and the amount of ore in it, even if it is continuous in all directions, is necessarily small, as the projected plane of the vein comes to the surface everywhere within a few hundred feet of the main tunnel. On the east side of the mountain a 30-foot tunnel, driven on the same vein, is not now accessible. The ore is reported to be "spotted," rich ore being closely succeeded by almost barren quartz. No work was being done on this property at the time of visit.

SAN JUAN PROSPECT.

The San Juan group of two claims is on the crest of the high mountain ridge which forms the west valley wall of Little Susitna River just north of Fishhook Creek. The open cuts on these claims were not seen by the writer, but it is reported that a gold-bearing quartz vein 9 feet wide has been exposed. Pieces of ore said to have been taken from the property appear to be pegmatitic in character, with large quartz and feldspar crystals. If this rock proves to be workable ore it is of different character from the other proved ore bodies of the district.

SHOUGH PROSPECT.

The Shough prospect is located on the Oregon group of claims, on the west side of the Little Susitna Valley 2 miles north of Fishhook Creek. The camp and workings are at an elevation of 3,550 feet, or 1,800 feet above Little Susitna River. Development work on these claims was begun in the spring of 1913, and the improvements consist of tents, a blacksmith shop, a horse trail built from the main valley trail to the workings, an adit tunnel which at the time of visit was 35 feet long, a shallow shaft, and several open cuts.

The shaft was sunk on "vein No. 1," a quartz vein which strikes N. 13° E. and dips 62° W. It is reported that the vein, which cuts a pinkish decayed diorite country rock, reached a maximum thickness of 15 inches. On the mountain slope below the shaft an adit tunnel was driven for the purpose of intersecting the No. 1 vein. In this adit another quartz vein with a greatest thickness of 12 inches was encountered and followed. The vein strikes in general about N. 36° W. and dips 45° E., but both strike and dip vary greatly within short distances. The country rock near the tunnel breast is a dark blue-gray diorite, and the quartz is considerably shattered and much stained with copper carbonate.

A third vein, imperfectly exposed in open cuts, is said to reach a width of 3 feet. Its general strike is east and its dip 68° N.

Notwithstanding the high assays reported from these veins, the vein matter shows little or no free gold and yields unsatisfactory returns when mortared and panned. The principal visible metallic minerals present are azurite, what appears to be chalcocite, iron oxide, and some galena. In the shallow depths reached, however, the quartz is more or less oxidized, and the iron oxide probably represents original pyrite. Insufficient work had been done at the time the property was visited to determine the permanency of the veins or to learn the average gold content in any considerable quantity of ore.

The Shough prospects lie just east of the line of a fault zone cutting the diorite. This fault has been traced for a distance of over 2 miles in a northeast direction, and several prospects have been located near it. The relation of this fault to the veins near it has not yet been determined, as only a small amount of development work has been done along it and the surface exposures are unsatisfactory. It may be, however, that the fault has offered a passage through which mineralizing solutions have circulated, and that the veins near it have a close genetic relation to the fault.

SUMMARY.

Lode mining began in the Willow Creek district in 1908, and since then some $300,000 worth of gold has been recovered. The actual recovery from the ore that has been milled is $42 a ton in gold with some silver. This does not include the values contained in the concentrates or in several thousand tons of tailings which have been stored for future treatment. It is probable that the actual gold content of the ore crushed averages at least $50 a ton. These figures are borne out by the assay returns kindly furnished by various operators.

The veins already shown are in general parallel to pronounced systems of jointing. Though not yet mined to any great depth, individual veins have been traced to considerable distances on the surface. There is no reason to believe that the veins will not be persistent at increased depth. Below the zone of oxidation, which does not exceed a few feet in thickness, they should show no greater variation in value than within the present limit of mining.

The occurrence of this zone of mineralization along the contact of intrusive granodiorite is similar to that of some of the gold deposits of southeastern Alaska and elsewhere in the Territory. The geologic evidence at hand is all in favor of the presence of commercial ore bodies in this district.

The present operating costs are high, owing to the facts that transportation from Knik is effected by wagon and that this port can be reached by ocean freight only from May to November. It is estimated that thus far the freight charges to the mines have varied from $50 to $85 or more a ton. Operations have also been hampered by the lack of water at the altitudes at which mills have been installed and by the great cost of fuel. Many of these conditions will be overcome if the Willow Creek district is made tributary to one of the proposed railroads into the Yukon or Kuskokwim basin.

MINERAL RESOURCES OF THE UPPER MATANUSKA AND NELCHINA VALLEYS.

By G. C. Martin and J. B. Mertie, Jr.

INTRODUCTION.

The district described in this report comprises the upper half of the Matanuska Valley and a contiguous area on the headwaters of Nelchina River, which is tributary to the Copper through the Tazlina. It includes parts of the eastern Talkeetna and northern Chugach mountains, which are separated by the valley of Matanuska River. The district consists of moderately rugged mountains 5,000 to 7,000 feet high, which grade eastward into the rounded hills, about 4,000 feet high, lying on the western margin of the Copper River Plateau.

The Matanuska Valley can be reached either from Knik, which is the head of navigation on Cook Inlet and to which vessels of shallow draft can go at high tide, or from Cordova or Valdez by way of Chitina and Tazlina road house. Near the lower end of Knik Arm there is a good anchorage, which ocean-going vessels can reach at any stage of the tide except during the winter, when the upper part of Cook Inlet is frozen or filled with floating ice.

At present freight can not be taken in by way of Cook Inlet during the winter, as the inlet is usually blocked with ice from November 1 to May 1. Passengers can reach the region during the winter by going in from Seward with sleds, but the Seward route is not [illegible] for heavy freight. The best winter route to the upper Matanuska and Nelchina district is by way of Chitina or Valdez. The distances from Chitina and Valdez to the headwaters of the Matanuska by way of Tazlina road house are 125 and 170 miles, respectively.

A good wagon road has been built from Knik to Little Susitna River. From mile 25 on this road a trail has been cut for a distance of about 8 miles, to the mouth of Moose Creek, where it joins the old Matanuska trail from Cottonwood.

The trail from Moose Creek up the valley reaches Chickaloon River about 24 miles from Moose Creek. From the Chickaloon ford the trail ascends on a good grade until it reaches the forks near the south end of Boulder Creek flats, a distance of about 7½ miles. From this point the Nelchina district may be reached by either of three routes, by the old Matanuska trail around Sheep Mountain, by the Hicks Creek trail, or by way of Boulder Creek.

The old Matanuska trail extends east along the southern base of Anthracite Ridge to the forks of the Hicks Creek trail at Index Lakes, a distance of 11 miles. The trail turns east at Index Lakes and crosses Hicks Creek at a distance of a mile and a half. From Hicks Creek to Caribou Creek, about 10 miles, the trail lies parallel to the river. After crossing Caribou Creek it follows the southern slope of Sheep Mountain. About 13 miles east of Caribou Creek it passes through a saddle at the east end of the mountain, descends to Squaw Creek, and goes up the Squaw Creek valley for about 5 miles, whence it turns northward along the western margin of the Tazlina Valley. The headwaters of Crooked Creek may be reached by turning up the hill at the lake about 4 miles above the Squaw Creek crossing. By the route thus described the junction of Albert and Crooked creeks is about 55 miles from Chickaloon ford, or about 110 miles from Knik.

The Hicks Creek trail leaves the Matanuska trail described above at Index Lakes; going up the valley of Hicks Creek to its head, a distance of about 10½ miles; down Divide Creek to Caribou Creek, about 3 miles; down Caribou Creek about 3 miles, to a point half a mile above the mouth of Alfred Creek, where it turns east to avoid the canyon half a mile up Alfred Creek; then up Alfred Creek for about 10 miles to the point where the main creek comes from the northwest; thence northeast for 3 miles. From Albert and Crooked creeks it is about 48 miles to the Chickaloon ford and 103 miles to Knik by this route.

The Boulder Creek trail turns up Boulder Creek flats at a point 7½ miles east of Chickaloon ford and follows the open gravel bars of Boulder Creek for about 13 miles. It then climbs sharply and reaches the summit of a pass about 3 miles distant, at an elevation of 4,800 feet. From this summit it descends into Caribou Creek. For about 3 miles, or nearly to timber line, the trail follows the creek closely, then climbs up the western bank, which it follows to the mouth of Chitna Creek. Thence it follows the gravel bars for about 3 miles to the mouth of Divide Creek, where it joins the Hicks Creek trail. By this route it is about 51 miles from Albert and Crooked creeks to Chickaloon ford, or about 106 miles to Knik.

Timber line in this district is at a general elevation of 2,500 to 3,500 feet, above which there is the customary growth of small bushes, moss, and grass. The trees include spruce, birch, and several kinds of cottonwood. The growth is in general not dense. Most of the spruce trees are under 12 inches in diameter, and the largest one which the writers noted had a circumference of 5 feet. The timber is moderate in amount and of only fair quality, but, except in the higher valleys, it is probably sufficient for local demands, provided that forest fires, which the dry climate favors, are kept under control. The local supply of timber will probably prove inadequate as soon as extensive mining is undertaken. There is no timber suitable for export.

The more open birch forests, as well as the areas which have lately been burned, are covered with a dense growth of grass, chiefly redtop. There are also large areas of bunch grass above timber line at some localities, especially in the eastern part of the district. These natural meadows are large enough to furnish feed for whatever stock is likely to be locally needed.

GEOLOGY.

West of Chickaloon River the Talkeetna Mountains are probably composed chiefly of granite, although metamorphic rocks and small bodies of sedimentary rocks are known to be present. East of the Chickaloon the Talkeetna Mountains are made up of stratified rocks of Jurassic and Cretaceous age, including both sedimentary and volcanic beds, overlain in parts of the area by Tertiary conglomerate and lava and tuff. The rocks immediately south of the Matanuska include Tertiary and Upper Cretaceous sediments, volcanic rocks of probable Lower Jurassic age, schists, and granitic intrusives. The geology of that part of the Chugach Mountains which lies south of a belt bordering the river is practically unknown, but the rocks are probably in the main crystalline and largely metamorphic.

The general stratigraphic sequence is given in the following table:

Stratigraphic sequence in the Matanuska Valley.

Age.		Lithologic character.	Thickness (feet).
Quaternary.		Alluvium.	
		Glacial and high-level terrace gravels.	
Tertiary.	Pliocene (?)	Basaltic lavas, breccias, and tuffs.	1,000+
	Miocene (?)	Eska conglomerate.	2,500
	Eocene.	Chickaloon formation; coal-bearing shale and sandstone with the flora of the Kenai formation.	2,000±
		Arkose, conglomerate, and shale.[a]	2,000±
Upper Cretaceous.		Shale and sandstone.	4,500±
Lower Cretaceous.		Limestone.	300±
Upper Jurassic.		Shale, sandstone, and conglomerate.	1,000±
Middle Jurassic.		Shale and sandstone carrying the fauna of the Chinitna shale of Cook Inlet.	2,000±
		Sandstone with the fauna of the Tuxedni sandstone of Cook Inlet.	1,000±
Lower Jurassic.		Andesitic greenstone, tuffs, agglomerates, and breccias; rhyolites, dacites, and tuffs.	3,000±
Early Mesozoic or older.		Graywackes, slates, basaltic, greenstones, and rhyolites, and tuffs of the Knik River district.	(?)
Paleozoic.		Mica schists and other schistose and gneissic rocks.	(?)

[a] The stratigraphic position of these rocks is not definitely established. They may include beds equivalent to part of the Eska conglomerate and Chickaloon formation, as well as beds older than the Chickaloon. (See pp. 285-286.)

MINERAL RESOURCES.

METALLIFEROUS DEPOSITS.

GENERAL CONDITIONS.

The geologic formations of this district which seem most likely to carry valuable metalliferous deposits are the schists and the Lower Jurassic volcanic rocks.

The schists south of the Matanuska are in general similar to the gold-bearing schists of Willow Creek, but, unlike those rocks, they have not yet been found to contain gold-bearing veins or to be the source of gold placers. Their area is not easily accessible and has probably not yet been thoroughly prospected.

The Lower Jurassic volcanic rocks have been in general considerably altered. They are extensively fractured and at many places contain multitudes of small calcite veins or are impregnated with much fine disseminated pyrite. The copper deposits described on pages 281–282 occur in these rocks, which have not elsewhere been proved to contain valuable deposits. Paige and Knopf[1] said of these rocks:

> Though placers have not been found within the areas of older volcanic rocks, mineralization has occurred. West of Hicks Creek a large cropping of gossan about 100 feet wide was found. This red capping is due to the oxidation of finely divided pyrite disseminated through a quartz porphyry. A sample selected for assay showed a trace of gold and no silver.

The Middle and Upper Jurassic, Cretaceous, and Tertiary beds and the intrusive rocks which cut them are not known to contain metalliferous deposits, although there is a possibility (see p. 280) that some of the placer gold is derived from the small veins in the Middle Jurassic shale and sandstone or in the dikes which cut those beds, or from the Tertiary conglomerate.

The extensive Quaternary gravels at the head of Matanuska River may contain small amounts of finely disseminated placer gold, but are not likely to be either of direct economic importance or even the indirect source of reconcentrated placers. Their glacial origin is unfavorable to the occurrence of extensive placer deposits, as their rapid mode of accumulation precluded the sorting and concentration which is necessary for the formation of workable placers.

The present stream gravels are largely derived from the reworking of these older gravel sheets. Even with this partial reconcentration the gold content, at least in most places, has not been increased sufficiently to pay for working. Productive placers are more likely to be found on such streams as are directly engaged in eroding a gold-bearing bedrock, especially rock containing mineralized quartz stringers.

---

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, p. 65, 1907.

PLACER GOLD.

INTRODUCTION.

The stream gravels of the upper Matanuska and Nelchina district had been prospected for many years prior to 1913 without marked success. Promising indications of workable placer ground have been reported many times from various places, but owing either to the difficulty and cost of transporting supplies, or to lack of diligence in prosecuting the work, or to the lack of the gold itself, no producing mines have developed.

Interest in this district was renewed in 1913 by the discovery of workable placers on Albert Creek, a small tributary of Crooked Creek, which flows into the Nelchina. About 65 ounces of gold was obtained in a few weeks from the Discovery claim. Probably only about 20 men were in the district during the working season, and most of these accomplished little or nothing except the requisite amount of assessment work. At the close of the season 100 or more prospectors went in from Knik, Valdez, and other places and a large amount of ground was staked. It is to be hoped that sufficient machinery and supplies were sledded in during the winter to test the district adequately during the coming summer.

ALBERT AND CROOKED CREEKS.

Albert Creek is a small stream which enters Crooked Creek from the west about 9 miles above its mouth, at an altitude of about 3,500 feet. Albert Creek has two named tributaries—Dick Creek, entering it from the southwest about 2,200 or 2,300 feet above Discovery, and Porphyry Gulch, entering it from the north at about the center of claim "No. 2 above." Crooked Creek, to which Albert Creek is tributary, flows into Nelchina River, which in turn is tributary to the Copper through Tazlina River. Crooked Creek, so named from its meandering course, flows at a low gradient over swampy bottom lands where the depth to bedrock is not known and may be considerable. The country surrounding Albert Creek consists of low, rounded hills which, like the valley of that creek itself and of the other tributaries of Crooked Creek, are entirely devoid of timber. Small cottonwoods and willows grow along the creek, but even these are few. The nearest timber is about 3½ miles east of the mouth of Albert Creek, on the edge of the Copper River flats. There is also timber about 8 miles to the northeast, near the mouth of Crooked Creek, and about 9 miles to the southwest, on Alfred Creek. At none of these places is the timber abundant or of good quality, but at any of them enough can be obtained to supply a small camp with houses, sluice boxes, and fuel. There is abundant bunch grass along the upper slopes of Albert Creek and probably at numerous other localities in the vicinity.

The rocks exposed along Albert Creek are mostly sandstones and shales, probably of Middle Jurassic age. They dip at moderately steep angles and are cut by dikes which are mostly small. The hill south of the lower course of the creek consists of altered igneous rocks which were regarded by Paige and Knopf[1] as "lower Middle Jurassic" (subsequently called Lower Jurassic) greenstones. There is a possibility that these rocks are altered intrusives. Albert Creek heads at the east end of a ridge capped by late Tertiary lavas. These may be underlain by Tertiary conglomerate, as they are at other localities farther west. If this conglomerate is here present it is a probable source of the placer gold. Bench gravels probably occur in the valley of Albert Creek, but they were not noted by the writer, there being snow on the ground when he was there. They were observed, however, in the valley of Crooked Creek 2 miles southeast of Albert Creek, up to an elevation of at least 3,800 feet.

Placer gold was discovered on Albert Creek by Fred Getchell, Duncan McCormick, and O. D. Olsen in 1912. The first ground was staked in March and April, 1913. In August, 1913, claims had been staked from "No. 4 below," which lies at the mouth of Albert Creek, crossing over Crooked Creek, to "No. 7 above," and also on Dick Creek and Porphyry Gulch, two of the tributaries.

Sluicing began on the Discovery claim on July 12, 1913, and at the close of the season, about September 1, it was reported that 65 ounces of gold had been obtained. The gold is bright and clean and well rounded, of very uniform size, a large proportion being worth from 1 to 3 cents and the largest nugget found being 1½ pennyweights.

From 3½ to 4½ feet of gravel was shoveled in. This was said to run as high as $14.50 to the yard and to average about $6. The gold-bearing portion is said to extend throughout a width of 30 feet, with only one side found. It lies on a shale bedrock, and has about 9 feet of overburden.

Only prospecting and assessment work was done on other claims than Discovery. Claims were staked and gold reported to be found on Crooked Creek and on several of its other tributaries, including North Creek and South Creek, which enter Crooked Creek from the west half a mile north and 1 mile south, respectively, of Albert Creek, and on Sleigh Creek, which enters it from the east near the mouth of North Creek.

ALFRED CREEK.

Alfred Creek is a large stream tributary to Caribou Creek from the east about 13 miles above its mouth. The upper part of the valley is open and lies among rounded hills, but the lower part is deeply incised, the creek passing through several canyons, of which the low-

---

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, Pl. II, 1907.

est one, which is about half a mile long, terminates about half or three-quarters of a mile above the mouth of the creek in a broad flat. The trail follows the creek except at this lower canyon, which it avoids by passing over the bench to the north. A moderately dense growth of small spruce extends along the lower half of the stream. In the upper part of the valley there is no vegetation larger than willows and small cottonwoods along the stream course. There are numerous patches of good grass on the hillsides.

The rocks exposed along the upper half of Alfred Creek consist of Jurassic sandstones and shales cut by small dikes. Along the lower half of the creek the only rocks exposed are Upper Cretaceous shales, except at the lower end of the lowest canyon, where there is a large dike of coarse diabase. The rocks exposed on the tributaries are probably in large part the same as those on the main creek, except that the high ridge north of the creek is known to be capped by Tertiary volcanic rocks. These may be here, as they are at so many places in this district, underlain by Tertiary conglomerate. If so, this conglomerate is a likely source of the placer gold.

Alfred Creek has apparently been staked throughout the greater part of its length, but on only a few claims has more than technical assessment work been done. The discovery was made in 1911. A total of about $1,500 of gold is said to have been recovered from this creek.

MAZUMA CREEK.

Mazuma Creek is tributary to Caribou Creek from the northeast at an altitude of about 3,300 feet. The lower part of its course is in an inaccessible canyon, but the upper open part of its valley may be reached by a trail leading across the hills from the mouth of the stream entering Caribou Creek next below Mazuma Creek. The entire valley is above timber line and contains no vegetation larger than moderate-sized willows and small cottonwoods. The nearest timber is on Caribou Creek about 2 miles below Mazuma Creek, where there is a sparse growth of small spruce. Grass is abundant along the trail leading into the upper Mazuma Valley.

The rocks on Mazuma Creek are basaltic lavas and tuffs, underlain along the upper part of the creek by coarse conglomerate. An exposure at an altitude of about 4,600 feet shows coarse, poorly consolidated conglomerate overlain by angular blocks of lava which were probably transported from the hillsides above. The conglomerate is well consolidated near creek level, but looser above. This difference may be either the result of local cementation, local leaching, or reworking. It is probably due to reworking, for the looser part is decidedly coarser than the well-consolidated conglomerate at the creek level. The well-consolidated conglomerate consists of bowlders, in general not over 6 inches in diameter, and contains lenses of shale and sandstone, while the looser conglomerate has numerous bowlders from 1 to 2 feet long. The bowlders are chiefly granitic and fine-grained igneous rocks with some sandstone, shale, and porphyry. The conglomerate, both above and below the contact of the better and the less consolidated part, is thoroughly indurated along vertical fissures which stand out like dikes. The creek gravels, so far as noted, contain only material which might be derived from the conglomerate or the overlying volcanic rocks and include numerous large bowlders.

Claims have been staked from 3 to 5 miles above the mouth of the creek. The discovery was made in 1906. Nuggets up to 16 or 18 cents in value are said to have been found. It is reported that a large number of them have "cement" sticking to them. There has apparently been little or no production from this creek. The improvements consist of a wing dam, several prospect holes, and a ditch which will deliver water from a tributary stream under moderate head.

Whatever gold occurs in the gravels of Mazuma Creek was probably derived by reconcentration from a more disseminated deposit in the conglomerate. If there is, as there appears to be, a loose reworked conglomerate lying upon and derived from an older and more thoroughly indurated conglomerate, the contact of the two is possibly gold bearing.

NELCHINA RIVER.

Nelchina River itself was not visited by the writers, and no later information is at hand than that published by Paige and Knopf,[1] as follows:

> Two prospectors from Copper Center, who were met in the headwater country of the Nelchina and Tyonek rivers, reported that gold was present in all the stream gravels, but in very small quantities. The gold obtained on the Tyonek is almost exclusively in the form of small round plates, worth about a cent apiece. Occasional small shotty nuggets occur, not exceeding 5 or 10 cents in value.
>
> It is reported that the hard conglomerate interstratified with Jurassic shales and sandstones, when panned, failed to yield colors. Yet in view of the unaltered and unmineralized character of the prevailing sandstones and shales, and in view of the comparative coarseness of the gold, it is nevertheless probable that the meager gold content of the present stream channels has been derived by a concentration of the ancient conglomerates.

SOURCE OF THE GOLD.

The source of the placer gold in this district is not known. There seem to be at least three possible sources—(1) concentration from small veins in the bedrock, (2) reconcentration from disseminated gold in the glacial gravels, and (3) reconcentration from disseminated gold in the Tertiary conglomerate. It may be that there is either a general source, which will account for all the placer gold, or that the various occurrences have sources of different kinds. If the latter

---

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, p. 67, 1907.

possibility is admitted, then none of the three sources suggested above can be denied, and the problem must be dismissed until further local evidence is obtained.

If one general explanation is insisted upon, then it may be concluded that the source can not be assigned to local mineralization of the bedrock, unless it is assumed that the rocks of Alfred and Crooked creeks and those of Mazuma Creek have been mineralized. The former include Jurassic and Cretaceous sandstones and shales cut by small dikes; the latter include Tertiary lavas, tuffs, and conglomerates. In none of them are veins conspicuous. This explanation, as a general one, accordingly seems improbable.

Reconcentration from glacial gravels will not answer as a general source, for such gravels are not present on Mazuma Creek. This explanation would perhaps serve for the deposits on Crooked and Alfred creeks if it were assumed that these streams lie in the course of an ancient spillway from the Copper River basin. Such is apparently not the case, however, for the valleys of Squaw Creek and of the main headwaters of the Matanuska would naturally serve as such a spillway rather than the higher divide between Crooked and Alfred creeks.

Reconcentration from disseminated gold in the Tertiary conglomerate will not explain all these occurrences unless it is assumed that the Tertiary lavas on the headwaters of Alfred and Albert creeks are underlain by such a conglomerate. It is not known positively that the conglomerate is present there, but probably it is. However, this conglomerate has not yet been shown to be gold bearing, although similar conglomerates in other places probably carry gold.[1]

COPPER.

There is an interesting occurrence of copper ore on Sheep Mountain, near the headwaters of the Matanuska.[2] Sheep Mountain is an isolated rugged mountain mass lying north of the Matanuska, east of Caribou Creek, south of Squaw Creek, and west of Tahneta Pass. The rocks composing the mountain consist of andesitic tuffs, breccias, and lavas of Lower Jurassic age, with some interbedded shale, sandstone, and chert. They have been intruded by at least one mass of granite. The volcanic rocks are greatly shattered, and are traversed by a network of small veins which consist mostly of calcite. Considerable alteration has taken place. These rocks were described by Paige and Knopf[3] as follows:

> For several miles the whole southern flank of Sheep Mountain, at the head of Matanuska River, is colored a strong red from the oxidation of pyrite in the greenstones. At

---

[1] Prindle, L. M., A geologic reconnaissance of the Circle quadrangle, Alaska: U. S. Geol. Survey Bull. 538, p. 57, 1913.

[2] Brooks, A. H., The mining industry in 1912: U. S. Geol. Survey Bull. 542, p. 39, 1913.

[3] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, p. 65, 1907.

> some points the sulphuric acid formed during the oxidation of the pyrite has bleached the greenstones to a pure-white color. The rugged range, thus tinted in vividly contrasting colors, presents a marked scenic effect. Certain streams emerging from the range are so highly charged with iron salts as to color their gravel red with oxide. The pyritization of the greenstones, which are here roughly schistose, has affected a great thickness of rocks but is of a diffused character. An assay of a sample selected as showing the maximum mineralization yielded only a trace of gold and no silver.

The copper prospects are on East End Creek, which heads just west of the easternmost high peak in Sheep Mountain, and is the third creek west of the eastern extremity of the mountain. It enters the Matanuska about 7 miles above Caribou Creek, or 2 miles above the forks of the Matanuska.

The copper ore apparently occurs as irregular lenticular masses in the more porous and shattered parts of the rock. The abundance and wide distribution of small fragments of copper ore on the talus slopes indicate that the mineralization is general rather than localized and apparently promise the discovery of many small, lenticular ore bodies rather than a few large, persistent ones.

A mineralized zone was observed by the writers on the west bank of the creek at an altitude of about 4,200 feet, near the upper forks. It trends N. 40° E. and stands about vertical, being approximately parallel to the bedding. Disseminated sulphides (mostly chalcopyrite) occur in small masses throughout a width of about 5 feet, and the zone is thoroughly stained with malachite and a little azurite. Specimens (No. 252) taken at this locality were found to contain chalcopyrite, malachite, a little pale-blue carbonate, quartz, and calcite. Veins containing quartz, calcite, chalcopyrite, etc., occur in a shattered basic igneous rock. The chalcopyrite is weathering to copper carbonates. Specimens (No. 252–a) obtained in the creek bed and on talus slopes near by contain bornite and chalcopyrite. The gangue appears to be quartz, epidote, and calcite. The copper sulphides are weathering to malachite. A specimen (No. 251) obtained at the camp site at the mouth of the gulch of East End Creek, which is believed to have been obtained on this creek, appears to represent a sulphide replacement of basic igneous rock. The copper sulphides, which appear to be bornite and chalcocite, are altering to malachite. Epidote occurs in the gangue.

COAL.

AREAL DISTRIBUTION.

The coal of the Matanuska Valley occurs in several detached fields, part of which lie within the area here described and part of which are in the lower Matanuska Valley, a description of which has already been published.[1]

---

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

The coal of the upper Matanuska Valley is found in two separate fields which are distinct not only areally but in the geologic occurrence and probably in the character of the coal. One of these two fields (neither of which may be strictly a unit) lies in the Matanuska Valley proper below Hicks Creek, including the Anthracite Ridge area and an area south of the Matanuska, and is the eastern extension of the Chickaloon, Kings River, and Coal Creek area of the lower Matanuska Valley. The other is the upper Boulder Creek and Caribou Creek field.

The areal extent of the assemblage of rocks which carry the coal is indicated on Plate XI. The areas indicated as coal-bearing are those which may carry coal, as distinguished from the areas shown in blank on the map, which are believed not to carry coal. The areas represented as probably coal bearing, or as containing the so-called "coal-bearing rocks," can not be assumed to be underlain wholly by beds of coal of workable character and thickness. Moreover, parts of these areas probably have no coal under them. The lack of knowledge as to the exact stratigraphic position of the coal beds, the uncertainty as to what stratigraphic part of the "coal-bearing rocks" is represented by each of the observed surface outcrops, and the concealment of the rocks by gravels over broad areas make the precise areal distribution of the coal a problem which can be solved only by drilling or other underground exploration.

The tables given below indicate the probable and possible areas of supposed "coal-bearing rocks" in the lower Matanuska Valley as previously published [1] and with subsequent revision. The Chickaloon and Kings River area and the area south of the Matanuska, as given in the first of these tables, include lands as far east as longitude 148° 20′, as is shown on Plate VIII of Bulletin 480. These are larger tracts than were described in detail in Bulletin 500 and include land lying in the area described in the present paper. The first of these tables shows the areas of probable coal or the areas known to be occupied by the so-called "coal-bearing rocks," as defined above, and by the conglomerates and other beds which overlie them. The second table shows the areas of possible coal or the areas which may also be underlain by these rocks, but in which, because of concealment by gravels or of other lack of definite information, there is a possibility that other formations may be present. These estimates when first published were described as "provisional and subject to modification, perhaps considerable, when the region is more thoroughly prospected." It should be noted that they have already been modified by the later geologic work, which has shown that part of the area, east of Chickaloon River and both north and south of the

---

[1] Martin, G. C., Preliminary report on a detailed survey of part of the Matanuska coal fields: U. S. Geol. Survey Bull. 480, p. 134, 1911. Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, p. 76, 1912.

Matanuska, included in the 44 square mile and 8 square mile items, is not occupied by the coal-bearing Chickaloon formation, but by the non coal-bearing marine Upper Cretaceous, while another part of the 44 square mile area is occupied by a conglomerate of uncertain horizon which contains no coal outcrops and may not be underlain by coal.

Areas of supposed coal-bearing rocks in the lower Matanuska Valley.

[Square miles.]

	Original estimate.	Revised estimate.
Valleys of Chickaloon and Kings rivers	44	41.1
South of Matanuska River in vicinity of Kings Mountain and Coal Creek	8	6.4
Valley of Young Creek	3	3.0
Valleys of Moose and Eska creeks	19	19.8
	74	70.3

Areas of possible extensions of the supposed coal-bearing rocks in the lower Matanuska Valley.

[Square miles.]

	Original estimate.	Revised estimate.
Lower parts of valleys of Kings River and Granite Creek	8	9.1
Valleys of Moose and Eska creeks	16	15.8
	24	24.9

The following tables contain similar estimates of the areas which probably or possibly contain some coal in the upper Matanuska Valley proper, below Hicks Creek:

Areas of probable coal-bearing rocks in the upper Matanuska Valley.

[Square miles.]

Anthracite Ridge and low country south of its eastern half	22.7
South of the Matanuska near O'Brien Creek	3.0
	25.7

Areas of possible coal-bearing rocks in the upper Matanuska Valley.

[Square miles.]

Conglomerate and trap ridge district south of west half of Anthracite Ridge and of lower Boulder Creek	21.1
Alluvial flats of the Matanuska near O'Brien and Gravel creeks	3.2
Conglomerate area west of Gravel Creek	2.3
	26.6

These areas added to the revised estimates for the lower Matanuska Valley, as given above, show that the entire Matanuska Valley proper below Hicks Creek has an area of 96 square miles that probably contains some coal and an additional area of 51½ square miles that possibly contains some coal.

The area of coal on upper Boulder Creek and Caribou Creek can not, for reasons which will be discussed below, be estimated with even approximate certainty. The total area within which some tracts of coal may occur—namely, that of the conglomerate and of the overlying lavas (which may not everywhere be underlain by conglomerate)—is possibly 200 or 300 square miles, but it is reasonably certain that only a small fraction of this area is actually coal bearing.

STRATIGRAPHIC OCCURRENCE.

The coal beds of the part of the Matanuska Valley proper which is here under discussion, like those of the lower Matanuska Valley, are all known to be of Tertiary age and to agree approximately in general stratigraphic position with the coal of the Kenai formation on Cook Inlet. They all, except those at the Gravel Creek locality described as section No. 24 (p. 293), occur in the Chickaloon formation, which is the middle local division of the Tertiary rocks as described in the report on the geology of the lower Matanuska Valley. Their exact position within this formation has not been determined, but they seem to be in general distributed throughout the greater part of its thickness. Nothing definite is known as to the persistence of individual beds or of groups of beds.

The coal on Billy Creek and elsewhere in the Caribou Creek and Nelchina valleys has hitherto been assigned to the Jurassic, and has been described [1] as follows:

> The coal-bearing rocks of this [the northeastern] field include an area of about 500 square miles. Coal is found at various localities, but never in thick beds, the best discovered having a thickness of 3 feet. The rocks are of Jurassic age and from fossil evidence are divided into a Middle and an Upper Jurassic series. The character of the coal appears in a general way to be in accordance with this separation—that is, the older rocks carry bituminous coal, and the younger, coal of a lignitic character.
>
> The Middle Jurassic rocks generally are severely shattered and crushed, or sheared and slickensided, and as a rule present a decidedly unfavorable appearance for the presence of workable seams of coal. Locally the strata are closely folded, as on Billy Creek, where the coal has developed a strong cleavage and has assumed a semianthracitic character. That the high-grade coal is restricted to such belts of sharp deformation is rendered probable by the fact that the rocks in the less disturbed areas are found to contain only fragments of carbonized wood and small stringers of lignite.
>
> The Upper Jurassic strata lie in comparatively undisturbed attitudes, with prevailing low dips. Minor dislocations of the beds are of widespread occurrence. More extensive faulting is occasionally met with, as on Billy Creek, where faults of several hundred feet throw are revealed with diagrammatic clearness. Coal was seen at only two localities, on the head of Billy Creek and on the south fork of the Tyonek. At these localities the outcrops were obscured by mud and slide material, but the amount

---

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, pp. 56-57, 1907.

of coal represented was probably small. The coal found is a black lignite which checks on drying. Mendenhall reports thin beds of coal interstratified with the shales and sandstones along the south fork of the Nelchina.

The writers believe that at least the greater part of the coal in this district, and probably as much of it as occurs in distinct beds (that is, otherwise than as coalified sticks and small stringers), is not Jurassic but Tertiary. The evidence for this belief is as follows:

The coal-bearing rocks at the locality on Billy Creek described above contain abundant, well-preserved, and distinctive Tertiary plants. The lithologic character of the beds in which the fossils occur is similar to that of the recognized Tertiary rocks of the Matanuska Valley and entirely unlike that of the undoubted Jurassic rocks. The "greenstone amygdaloids" of the section on Billy Creek resemble some of the Tertiary igneous rocks at least as closely as they do the Lower Jurassic volcanic rocks, and consequently they may be regarded as either an infaulted block of late Tertiary basaltic lava or as an intrusive mass injected under light load.

A bed of coal exposed near the headwaters of Boulder Creek lies beneath the Tertiary lavas and above a massive conglomerate which rests upon Upper Cretaceous rocks. These coal-bearing beds carry fossil plants, which are either Upper Cretaceous or Tertiary.

Coal float was seen by the writer on several of the other tributaries of Billy and Caribou creeks, and in each place it was on a stream that heads in the conglomerate underlying the Tertiary lavas. No coal was seen by the writers in place in the Jurassic rocks, and no coal float was seen on streams other than those that head in areas of Tertiary rocks.

According to Knopf's notes coal was not seen in the undoubted Jurassic rocks except as "stringers" and was found as float only on those creeks (except for Tyonek Creek) which head in known or probable Tertiary areas.

There is consequently little doubt that the coal beds of this district are Tertiary. They evidently can not be assigned to the Chickaloon formation. The conglomerate with which they are associated may either hold the position of the Eska conglomerate or be the equivalent of beds lower down in the Tertiary sequence. It is believed that the beds at this horizon are only locally coal bearing.

COAL BEDS.

The following pages contain measured sections of all the coal beds that were accessible. These measurements were all made at natural exposures, there being no prospect openings or tunnels. No attempt has been made to correlate the beds, as the complex structure and the fact that none of the beds can be traced from point to point make correlation impossible. The sections in the Matanuska Valley proper are arranged in order from northwest to southeast.

1. Creek flowing northwest into Boulder Creek from near the west end of Anthracite Ridge, altitude 3,700 feet. Coal blossom (bed concealed) near outcrop of dark shale. Strike N. 68° W., dip 63° SW.

2. South face of Anthracite Ridge, 2 miles east of its west end, altitude 3,900 feet. Coal blossom. No exposure obtainable.

3. Creek bed 1.2 miles S. 52° W. from 6,280-foot peak at head of Purinton Creek, altitude 3,350 to 3,500 feet.

	Ft.	in.
Crumpled shale	85±	
Coal	1	1
Shale		6
Sandstone	21	0
Shale	25	0
Coal	1	0
Shale	25	0
Sandstone	18	0
Shale	18	0
Sandstone	36	0
Shale	3	0
Coal		8
Shale	12	0
Sandstone	24	0

Strike N. 62° W., dip 45° S.

4. West Fork of Purinton Creek, altitude 4,200 feet.

	Ft.	in.
Intrusive rock (diabase).		
Shale roof.		
Coal		6
Diabase sill		6
Shale		3
Coal with much shale	1	6
Shale		1
Very carbonaceous shale and coal		5
Shale.		

Strike N. 88° E., dip 43° S.

5. West Fork of Purinton Creek, altitude 4,100 feet. Apparently two beds of coal, each 5½ or 6 feet thick, 2 or 3 feet apart, but more probably one bed repeated by surface slipping. Strike N. 65° W., dip 30° SW.

6. West Fork of Purinton Creek, altitude 3,900 feet. Coal, 40± feet. Neither roof nor floor of this coal bed could be found. The coal is apparently cut off at each end of the exposure across what appears to be the bedding. This is the exposure which has previously been described [1] as a 38-foot bed of anthracite and of which an analysis is given on p. 295. It should probably be regarded as a swollen pocket lying in a closely folded overturned syncline and probably cut by a fault. An exposure of shale in the creek 15 or 20 feet below the coal gave three readings on the bedding as follows: Strike N. 72° E., dip 11° NW.; strike N. 76° W., dip 12° NE.; strike N. 73° E., dip 21° NW.

---

[1] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska, in 1905: U. S. Geol. Survey Bull. 289, p. 18, 1906.

7. West Fork of Purinton Creek, altitude 3,880 feet.

	Ft.	In.
Shale roof.		
Coal	1	0
Shale (some coal)		5
Coal	3	1
Shale	1	4
Coal	1	3
Shale with some coal		6
Shale	2	3
Shale with some coal	1	0
Shale	2	4
Coal	1	6
Black shale	1	4
Gray shale	12±	
Shale with some coal		6
Black shale	1	8
Coal	1	10
Shale		8
Coal with a little shale	1	4
Gray fissile shale floor.		

Strike N. 87° W., dip 55° S.

8. East bank of East Fork of Purinton Creek, about 570 feet upstream from section 9

	Feet.
Shale and sandstone, much folded.	
Coal with some shale	7±
Covered	6
Coal with some shale	4±
Shale and sandstone, much folded.	

9. East Fork of Purinton Creek, altitude 3,480 to 3,560 feet.

	Ft.	in.
Diabase.		
Shale (baked)	12	0
Sandstone	10	0
Shale, with coal blossoms	47	0
Coal	2	7
Shale floor.		

Strike N. 80° W., dip 55° S.

The section given below was measured by Martin[1] in 1905 on the east fork of Purinton Creek or on the next creek east of it, on the south slope of Anthracite Ridge.

	Feet.
Flaggy sandstone.	
Coal and shale	3
Coal	7
Shale	4
Coal	1
Shale	3
Coal	2
Shale	2
Coal	7

Strike N. 89° E., dip 55° SE.

---

[1] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska, in 1905: U. S. Geol. Survey Bull. 289, p. 19, 1906.

10. Creek bed 1.3 miles S. 24° E. from 6,280-foot peak at head of Purinton Creek, altitude 3,850 to 3,950 feet.

	Ft.	in.
Diabase sill	19	0
Shale	4	0
Coal	1	1
Partly shale, partly covered	21	0
Coal		8
Shale	15	0
Coal		10
Shale with thin sills	23	0
Coal	2	0
Shale (partly covered)	27	0

Strike N. 86° E., dip 44° N.

11. Creek bed 2.9 miles S. 55° E. from 6,280-foot peak at head of Purinton Creek, altitude 3,880 to 3,895 feet.

	Ft.	in.
Shale with coal blossoms	50	0
Coal	3	5
Shale	24	0
Coal	2	2
Shale	21	0

Strike N. 82° W., dip 20° N.

12. Creek bed 2.9 miles S. 54° E. from 6,280-foot peak at head of Purinton Creek, altitude 3,830 to 3,850 feet.

Shale roof.	Ft.	in.
Coal	1	2
Shale	3	8
Coal		9
Shale	2	2
Coal	3	2
Shale	1	1
Coal		7
Shale floor.		

Strike N. 82° W., dip 20° N.

The two following sections described by Paige and Knopf[1] were measured by Knopf on either this creek or the next one east of it:

Section of coal on Anthracite Ridge, altitude 3,100 feet.

	Ft.	in.
Diabase	50±	
Sandstone and shale	10±	
Coal and shale	6	0
Coal		2
Shale		1
Coal		10
Shale	2	0
Sandstone	7	0

Strike N. 70° W. (magnetic), dip 40° S.

---

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, pp. 55-56, 1907.

Section of coal on Anthracite Ridge, altitude 3,600 feet.

	Ft.	In.
Sandstone.		
Coal	2	6
Coal and shale		4
Coal		6
Coal and ferruginous clay		2
Coal [1]		10
Shale		6
Coal		4
Shale	12	0
Coal	1	3
Shale	5	0
Sandstone	1	0
Shale	1	6
Clay ironstone nodules		6
Shale	1	6
Clay ironstone nodules		6
Highly carbonaceous shale	5	0
Coal	1	5
Shale	9	0
Sandstone	4	0
Shale	15	0
Coal		10
Shale	4	0
Coal	2	2
Shale	4	0
Coal		10
Shale	2	6
Coal and shale		6
Shale footwall.		

Strike N. 80° E. (magnitude), dip 34° S.

13. Muddy Creek, altitude 3,700 feet. West bank of creek.

	Ft.	In.
Sandstone	20	0
Carbonaceous shale, locally coal		6
Coal	1	7
Shale	3	0
Coal	1	1
Carbonaceous shale		6
Shale, with flattened ironstone nodules	3	0
Coal	1	2
Shale		10
Ferruginous sandstone	1	2
Drab shale	1	7
Carbonaceous shale, locally coal		4
Coal		4
Carbonaceous shale, locally coal		6
Shale floor.		

Strike N. 32° W., dip 45° W.

---

[1] See analysis No. 22 in table of analyses, p. 295.

14. East bank of Muddy Creek, altitude 3,690 feet.

	Ft.	in
Shale roof.		
Coal	1	2
Shale	6	0
Sandstone	4	0
Shale	7	0
Coal	1	7
Shale parting		2
Coal	1	10
Shale	8	0
Sandstone	5	0
Shale	3	0
Coal	1	1
Shale	6	0
Coal	1	7
Covered.		

Strike N. 65° E., dip 45° S.

15. Bed of Muddy Creek, altitude 3,340 to 3,415 feet.

	Feet.
Diabase sill	100
Carbonaceous shales containing 6 to 12 coal seams ranging in thickness from 1 inch to 18 inches. Badly crushed and sheared	22
Sandstone, thin bedded, and shale	28

Strike N. 8° E., dip 25° W.

16. Crest of spur between Muddy Creek and Packsaddle Gulch, altitude 4,400 feet

	Feet.
Covered.	
Coal	11+
Covered.	

Strike approximately east, dip 90°±.

17. North bank of Matanuska River, half a mile above Gravel Creek.

	Ft.	in.
Fissile gray shale.		
Coal, clean	1	4
Coal, somewhat shaly		9
Fissile gray shale.		

Strike N. 49° E., dip 30° NW.

The entire exposure at this point consists of about 200 feet of shale and sandstone, with several carbonaceous zones 10 to 40 feet thick, in some of which there are coal beds several inches thick. The coal bed described above is near the base of the section and extends along the face of the bluff for a considerable distance, in which it shows no indication of lenticularity.

18. Gulch 0.3 mile west of O'Brien Creek, altitude 1,800 feet.

	Ft.	in.
Black shale with some coal.		
Gray sandy shale	8	4
Black shale		7
Coal		7
Gray nodular shale	3	3
Coal	2	0
Gray shale, much stained by iron		10

	Ft.	in.
Coal		9
Shale		2
Coal		4
Shale with a little coal	2	0
Ironstone band		9
Coal		7
Gray nodular shale	3	5
Coal		9
Shale		2
Coal	1	3
Concealed	8	0
Coal and some shale	6	0
Concealed.		

Strike N. 78° E., dip 40° S.

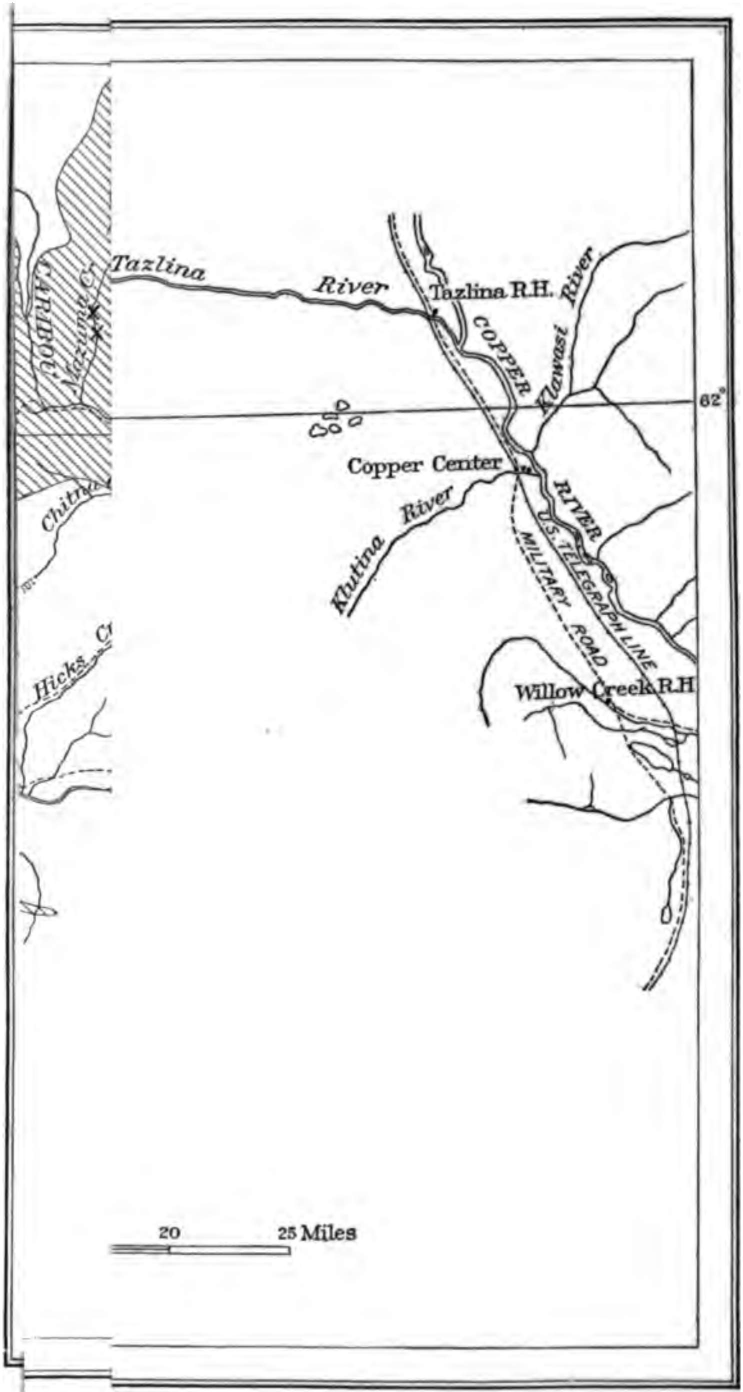
19. O'Brien Creek, altitude 1,500 feet.

Gray shale under clay.	Ft.	in.
Coal		½
Shale		1
Coal	4	1
Shale with some coal	1	9
Coal	1	6
Coaly shale		10
Coal	2	6
Shale with ironstone concretions	6	0
Shale and coal	4	7
Coal		2
Shale		1½
Coal	1	5
Shale		2½
Coal		11
Shale		¼
Coal		1½
Shale		¼
Coal	2	0
Coal and shale (squeezed)	1	6
Coal	2	8
Coal and shale		9
Shale	1	2
Coal	1	3
Coaly shale		10
Gray shale with ironstone concretions	13	6
Gray shale	31	0
Gray shale with ironstone concretions	3	0
Sandstone with some interbedded shale	14	10
Shale, somewhat sandy	15	0

Strike N. 70° W., dip 87° SW.

20. O'Brien Creek about 100 yards farther upstream. Coal with many thin partings, 25 feet. This bed is apparently below the one described above.

21. Near top of west bank of O'Brien Creek a short distance above No. 20. Large coal outcrop which apparently consists of the bed represented in section 20 folded back upon itself in an overturned syncline.


Tazlina
River
Tazlina R.H.
COPPER
Klawasi River
62°
CARIBOU
Mazuma Cr.
Copper Center
Chitna
RIVER
Klutina River
U.S. TELEGRAPH LINE
MILITARY ROAD
Hicks Cr
Willow Creek R.H.
20
25 Miles

MINER

22. Gulch one-third mile east of O'Brien Creek, altitude 1,800 feet.

Shale roof.	Ft.	in.
Coal	3	9
Coal and some shale	2	0
Concealed.		
Rocks dipping gently northeast.		

23. Gulch one-third mile east of O'Brien Creek, altitude 1,900 feet.

Sandy gray shale roof.	Ft.	in.
Coal		8
Shale with some coal	2	0
Sandy shale.		
Concealed.		
Rocks dipping about 20° NE.		

24. About 1½ miles up the creek which enters Gravel Creek from the west 2¼ miles above its mouth, altitude 2,100 feet.

Covered.	Ft.	in.
Coal, impure, sheared	1	7
Shale		7
Coal, impure, sheared	1	2
Covered.		
Dip 75° S.		

The rocks at this locality can not with certainty be assigned to the Chickaloon formation, which includes all the other known coal beds in the main valley of the Matanuska. The coal at this locality may represent either a local coal-bearing bed in the pre-Chickaloon strata, or a small block of the Chickaloon formation folded or faulted into the mass of rocks which are otherwise barren of coal.

Information concerning the coal of the upper Boulder and Caribou valleys is much less abundant than that already presented concerning the coal of the Matanuska Valley itself. This is due partly to the fact that the examination of this field was less detailed than that of the other, but chiefly to the fact that the field contains far less coal. The following is a typical section:

Section near waterfall on northwest side of Boulder Creek 16½ miles northeast of its mouth.

White sandstone and shale with carbonaceous beds.	Ft.	in.
Coal and shale	1	6
Coal [1]	1	3
Shale	1	0
Coal		7
White sandstone and shale.		
Strike N. 11° W., dip 20° NE.		

The exposure of coal-bearing rocks on the small tributary to Billy Creek from the east 2½ miles above its mouth contains numerous carbonaceous beds and coaly streaks and several thin beds of coal. The largest observed bed attains a maximum thickness of 3 feet, a large portion of which is shale and bone. The greatest observed thickness of pure coal at this locality is not over 12 inches.

---

[1] Included in sample No. 19346, p. 296.

Small fragments of coal were also observed in the beds of several of the other tributaries of Billy Creek, notably the one entering it from the east 6 miles above its mouth, on some of the creeks tributary to Caribou above Billy Creek, and on Hicks and Tyonek creeks.

CHARACTER OF THE COAL.

PHYSICAL PROPERTIES.

The coal of the Matanuska Valley is of three kinds—anthracite, high-grade bituminous, and low-grade bituminous. All of these have been found within the area here described. The last two occur also farther west in the lower Matanuska Valley and have been described in an earlier report.[1]

The anthracite is known only in a small area near Purinton Creek on the south face of Anthracite Ridge. The high-grade bituminous coal occurs on the south side of the Matanuska and probably on Anthracite Ridge. The low-grade bituminous coal occurs at the east end of Anthracite Ridge and on upper Boulder and Caribou creeks. The investigations that have thus far been made are not sufficient to permit an attempt to outline precisely or to estimate the areas of the several kinds of coal.

The anthracite has the ordinary physical characteristics of most coal of this kind. It is heavy, firm, hard, and not much fractured for surface coal and has a high luster. Pyrite was not observed in it.

The high-grade bituminous coal is fragile and soft, like all coal of this variety, and the beds show the effects of having been severely crushed and at many places are without any well-defined bedding planes or places of fracture. The friability of the coal is so great that it will probably not stand shipment without being badly crushed. This is not so great a detriment as might at first seem, because many of the beds contain so many impurities that the coal from them ought to be crushed and washed. It is, moreover, highly probable that some of this coal can be used in the manufacture of coke, a purpose for which lump coal is not desired. Coal which possesses coking properties, as much or all of this coal does, can, by proper handling, be burned as slack about as well as in lumps, for the slack coal when thrown into the furnace will fuse and cake, thus preventing loss of coal through the grates.

The low-grade bituminous coal is on the border line between bituminous coal and black lignite. It is harder than the higher-grade bituminous coal. Many of these beds too have been crushed, and a large proportion of lump coal can not probably be obtained from them. This coal probably possesses no coking properties and is likely to be used only under stationary or locomotive boilers. It is not so good

---

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

for this purpose as the higher-grade coal, but the latter, being better suited for the manufacture of coke and for use as smithing and naval coal, will command a higher price and may thus leave a lower-price market for the poorer coal. Some of the low-grade coal can probably be mined more cheaply than the high-grade coal. The two kinds of coal will, to a certain extent, be noncompetitive, each having its own special markets.

CHEMICAL ANALYSES AND TESTS.

The following table includes a few analyses of characteristic samples of coal from various parts of the area. Sample No. 19346 was taken during the investigations here described. The analyses of samples 1 and 22, which were collected in 1905 and 1906, have been published in Bulletins 289 and 327. The other analyses represent samples collected in 1911 by Dr. Joseph A. Holmes, Director of the Bureau of Mines. All the samples were obtained from surface prospects or from outcrops, and were consequently somewhat weathered. The reason that more samples were not obtained is that the absence of openings made it impossible to obtain other than samples of weathered coal, which are of comparatively little value.

Analyses and tests of Matanuska River coals.

Sample No.	Thickness of coal in feet.	Proximate analysis.					Ultimate analysis.					Calorific value.	
		Loss on air drying.	Total moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
[a] 1	38.0	([b])	2.60	5.26	86.15	5.99	0.57	3.07	84.30	1.13	4.94	7,586	13,655
19346	1.3		5.95	35.25	50.20	8.60	.43						
[a] 22	.9	([b])	2.18	30.60	50.06	9.16	.70	4.83	71.43	1.50	12.38	7,303	13,145

[a] These analyses were made by F. M. Stanton on the same samples as those with corresponding numbers on pp. 60, 61 of Bulletin 327. The differences in proximate analyses are due to the fact that the samples dried somewhat in the months which elapsed between analyses and that somewhat different methods of analysis were used. (See U. S. Geol. Survey Bull. 290, pp. 29–30, 1906.)

[b] Not determined.

1. West fork of Purinton Creek, altitude 3,900 feet. (See section 6, p. 287.)
22. South face of Anthracite Ridge. (See p. 290.)
19346. Near waterfall on northwest side of Boulder Creek 16½ miles above its mouth. (See p. 293.)

COKING PROPERTIES.

Comparatively little is known of the coking properties of the coal of this part of the Matanuska Valley. A rough coking test[1] made on some of the coal from Chickaloon River indicated that by proper treatment a coke of satisfactory grade can probably be produced.

No further tests have been made by members of the Geological Survey. The analyses indicate, however, that the high-grade bituminous coal of the upper Matanuska Valley, like that on Chicka-

---

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, p. 92, 1912.

loon and Kings rivers and on Coal Creek, is probably coking coal at least in part, and that such of the low-grade bituminous coal as is similar in composition to the coal on Moose, Eska, and Young creeks, in the west end of the lower Matanuska Valley, is probably noncoking.

MINING CONDITIONS.

The possibility of mining the Matanuska coal at a profit depends on a variety of factors, some of which are geologic and will be discussed below, while others, such as the cost of labor and supplies, purchase or leasing charges, transportation, and markets, are economic and do not belong strictly within the province of this report.

The geologic factors that affect the possibility of mining include the character of the coal, such as its composition, heating power, firmness, smoking and clinkering qualities, and coking or other special properties; the character of the coal beds, such as their thickness, persistence, freedom from partings and binders, and the nature of the roof and floor; the attitude of the coal beds, including their depth below the surface, steepness, and structural regularity; and the presence of extraneous detriments, such as intrusive rocks, water, gas, and dust.

A large number of these factors are variable within the field, either regionally or from bed to bed. These must be considered in detail, both locally and by beds, in connection with each proposed mining project, and they can not be the subject of a general discussion here. Others of these factors have already been considered in the preceding pages, so far as the available information permitted. There remain, however, several factors concerning which it is possible and desirable to present brief general discussions.

EFFECT OF FOLDING AND FAULTING.

The steep dips and complex structure of large parts of the coal areas introduce serious problems in coal mining and call for careful investigation of the structural conditions of each individual tract before the development of mines is attempted. It is believed that in some areas in the Matanuska Valley the structure is so complex that coal mining will be practically impossible. Such areas probably include at least part of Anthracite Ridge and part of the coal area south of the Matanuska.

The exposures on the north bank of the Matanuska from a point 1 mile above to a point 4 miles below the mouth of Gravel Creek show gently dipping and regular beds. If the coal exists beneath these beds there should be no difficulty in mining it. The distribution of the coal outcrops, which occur in two belts, one of them along the south face of Anthracite Ridge and the other south of the Matanuska, indicates that the broader structure of this part of the valley is synclinal and that the coal beds occur low in the stratigraphic sequence. In this case the center of the valley should be underlain by coal, but there is no evidence as to the depth at which the beds may lie.

The hill north of Boulder Creek and immediately east of Chickaloon River is composed of gently dipping Eska conglomerate. If the coal beds persist beneath the conglomerate, and if the coal-bearing rocks were not folded before the conglomerate was laid down, mining should not be difficult, at least so far as structural conditions are concerned. It should be remembered, however, that the vertical distance from the Eska conglomerate to the workable coal is not known and that the coal may at this point be at a prohibitive depth or under a prohibitive load.

Throughout the greater part of the main Matanuska Valley the structural details are not known, but there are indications that complex structure is the general condition. It is probable that there are areas in which the structure will permit the mining of the coal, but also that there are larger areas in which the structural conditions will make the mining of the coal difficult and expensive, if not impossible. It will probably be found that where the structure is simple the coal is of low grade. The character of the structure must be regarded as a problem to be solved by underground exploration before the feasibility of mining at a profit the coal of any particular tract can be demonstrated.

The coal areas on upper Boulder and Caribou creeks in general possess simple structure, although intense folding was noted on Billy Creek. (See p. 285.) In this district sharp folding is restricted to narrow zones between which the rocks are nearly flat. The coal of this district is, however, of small amount and low grade and is not easily accessible.

EFFECT OF INTRUSIVE ROCKS.

Intrusive rocks are abundant throughout the area of coal outcrops in the upper Matanuska Valley. They are both large and numerous along the south front of Anthracite Ridge in the area of both the anthracite and the low-grade bituminous coal. The areal distribution of the larger of these intrusive masses is indicated on the map (Pl. XI, p. 292). Small dikes and sills, not represented on the map, are also present throughout practically all the coal areas. Where the intrusive rocks cut the coal beds the coal is rendered worthless for a distance of a few inches from the contact. The small dikes and sills, on account of the short distances to which their effect extends, do not affect the coal seriously, except that the sills show a habit of seeking coal beds for their planes of intrusion. It is clear that if a sill is intruded into a coal bed for a long distance a large amount of worthless coal will result, but if it is intruded between rock strata, even if only a few feet away from a coal bed, or if it cuts across the coal bed in the form of a dike, its effect on the coal will be slight.

The larger intrusive masses are of much more serious importance than the small dikes and sills, first, because their size is of itself sufficient to reduce the coal areas considerably, and second, because each of them is likely to have sent off many apophyses in the form of sills in or along the surfaces of coal beds. The dimensions of these masses are, moreover, probably greater underground than at the surface. There may also be many intrusive masses which do not outcrop but which are near enough to the surface to be encountered in mining.

In conclusion, it must be stated that the presence of intrusive rocks in the coal field introduces factors that make an undetermined percentage of the coal areas of very doubtful value. The size and distribution of these intrusive masses beneath the surface, as well as at the surface in the areas of scanty outcrops, can not be determined without underground exploration. The effect of the smaller intrusive masses on the coal depends on the extent to which these masses have been intruded into or along the surfaces of coal beds. Where the intrusive mass is in contact with the coal the coal is worthless, but where it is a few feet away the quality of the coal is probably unimpaired or may even be improved.

UNDERGROUND WATER AND GAS.

In any large mines which are opened in this region it will be necessary from almost the beginning of mining to pump or hoist mine water. It is not believed that it will be possible to open any large mines having natural drainage. The amount of underground water which will be encountered will probably not be great, unless the mines are opened on the outcrop. Precipitation in this region is so slight that large amounts of water can get into the mines only from the streams. If ordinary precautions are taken to prevent streams from breaking into the mine openings the mines ought to be fairly dry.

The heavy cover of gravel which exists at the lower altitudes throughout most of the Matanuska Valley will cause certain dangers in mining. Unless the depth of the gravel at different points and the shape of the underlying rock floor are determined by drilling there will be danger of the mine workings breaking through the surface of the rock into the gravels. The gravels probably carry large amounts of water in some places and serious accidents might thus result.

Gas will probably be a serious problem in local mining from the very start. The experience of the tunnels on Chickaloon River indicates that these coal beds will yield large amounts of dangerous gases. Some provision ought to be made in advance of mining for the enforcement of suitable regulations insuring the protection of the miners and the mines against gas explosions.

CONCLUSION.

The outlook for profitable coal mining on a large scale in the upper Matanuska Valley is not promising. The doubt concerning the workability of the coal of the lower Matanuska Valley[1] applies with greater force here, where the coal is apparently of lesser amount and of lower grade, is folded and intruded to at least the same degree, and is less accessible than it is in the lower part of the valley. If mining is attempted in the upper Matanuska Valley the proposed mine sites should be selected only after a careful study of local conditions, which should be accompanied by drilling. The selection of a site should be governed by the accessibility to the railroad and by the structure of the rocks. The structure should be determined in detail for each property by careful drilling or otherwise, in order that the mine may be opened at such a point that the underground haulage of the coal and the disposal of the mine waters may be accomplished at a minimum expense.

Although many of the coal beds outcrop at the surface, they dip for the most part at steep angles. No localities have yet been found in this district at which it would be possible to mine any considerable amount of coal above the level of the outcrop of the coal bed. The amount of coal above the general drainage level is not great, and it will be necessary from the very beginning of mining to sink shafts or slopes to considerable depths. If any large mines are opened it will probably be found desirable to sink shafts to the coal beds at considerable distances from their outcrops.

The local region will furnish none of the supplies needed in coal mining, except timber, and even this is not abundant and is of poor quality. Everything else in the line of mine equipment and tools will have to be shipped from points outside of Alaska, which would add greatly to the expense of mining.

The development of the Matanuska coal fields on a large scale is dependent on the construction of a railroad to tidewater, and on the existence of an outside market for the high-grade coals. Under existing conditions of the mineral-fuel market on the Pacific coast it is only such coal as is suitable for coking, smithing, or for the Navy that will probably find such a market. The local conditions under which coal of this character has been observed indicate that its mining and preparation for market may be so expensive that it can not compete with high-grade coal from other regions.

The possibility of mining the low-grade coal at a profit is dependent either on the construction and operation of a railroad for other purposes than the shipping of such coal alone, or on the development of a local market. The latter may follow from the possible extensive development of gold mines.

---

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, p. 94, 1912.

PRELIMINARY REPORT ON THE BROAD PASS REGION.[1]

By Fred H. Moffit.

INTRODUCTION.

The Broad Pass region includes the upper parts of Chulitna and Nenana rivers. As here used, the name Broad Pass designates an area of indefinite boundaries, extending westward from Susitna River and for the most part lying south of the main axis of the Alaska Range.

The headwaters of Chulitna River and the vicinity of Broad Pass were first visited by Government exploring parties in 1898. In that year G. H. Eldridge[2] and Robert Muldrow, of the United States Geological Survey, ascended Susitna River from Cook Inlet to the mouth of Indian Creek, whence they made their way northeastward through the Indian Creek valley and a valley parallel to the upper Chulitna, which succeeds the Indian Creek valley, to Jack River. They then descended Jack River and the Nenana to the mouth of Yanert Fork, where the failure of their supplies obliged them to turn back.

The same year Sergt. Yanert,[3] of the Fourteenth Infantry, United States Army, with one companion and an Indian guide, ascended Chulitna River from a point near the mouth of Indian Creek to Broad Pass and Nenana River, but he, like the Eldridge party which preceded him a few days, was compelled by lack of food to return to Susitna River without seeing the Tanana.

Many prospectors and hunters have visited the region since that time. In 1903 a private reconnaissance railroad survey, crossing Broad Pass, was run from Cook Inlet to the Tanana, yet neither topographic nor geologic mapping was done in this region until 1913, although the adjacent Bonnifield and Valdez Creek districts were surveyed in 1910[4] and the exploratory expedition under Brooks[5]

---

[1] A more extended account of the Broad Pass region will be published in a forthcoming bulletin. Mr. J. E. Pogue has rendered efficient assistance in both the field and office work, of which this report is the result.

[2] Eldridge, G. H., A reconnaissance in the Sushitna Basin and adjacent territory, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 1-29, 1900.

[3] Yanert, William, A trip to the Tanana River: Explorations in Alaska, pp. 677-679, Washington, 1900.

[4] Moffit, F. H., Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdes Creek and Chistochina placer districts: U. S. Geol. Survey Bull. 498, 1912.

[5] Brooks, A. H., The Mount McKinley region, Alaska, with descriptions of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle: U. S. Geol. Survey Prof. Paper 70, 1911.

crossed the Nenana just above Yanert Fork in 1902. Plans were formulated for making such surveys in 1912, but could not be carried out on account of delay in the appropriation, although supplies had been sent to Valdez Creek in the early part of that year. The work was therefore not undertaken till 1913, when two parties were sent into the field. The season included less than 55 working days, and the working time was reduced still further by frequent rains and by a heavy fall of snow on August 27.

The Broad Pass country may be entered from the south by the Susitna River, Indian Creek, and Chulitna River valleys; from the north by the Nenana Valley; and from the east by any of the trails leading westward from the military road through the Valdez Creek district. There are no established trails leading into it, and each of the general routes mentioned presents difficulties of one kind or another. Nenana River is unfortunately too swift and has too many rapids in its course to afford a summer route from the Tanana for small boats. The Susitna-Chulitna route is long and difficult. The route from the east is perhaps the best for summer travel. Any one of the three may be used in winter, but the Nenana route is of course available only for those who are already in the interior of Alaska.

RAILWAY ROUTES.

Broad Pass offers one of the most favorable railway routes from the Pacific seaboard to the Tanana and Yukon basins. The Chulitna, flowing into the Susitna on the south, and Jack River, flowing into the Nenana, a tributary of the Tanana, on the north, both head in Broad Pass, which therefore marks the watershed between the Cook Inlet and Yukon drainage basins. The waters of the Nenana in the past ran through Broad Pass into the Chulitna but were diverted by the glacier that formerly occupied the region. Since the disappearance of the ice the drainage has not reverted to its preglacial course.

The approach[1] to Broad Pass from the south along the headwaters of the Chulitna is so far as known a gradual ascent, and a railway route of comparatively low grade could probably be found along it. The pass itself is a flat about 4 miles in width affording no engineering difficulties. It stands about 2,500 feet above sea level. North of the pass the railway route would be down the valley of Jack River to the Nenana, and here, too, a good grade could probably be found. The main Alaska Range would be traversed by the valley of the Nenana River, which for about 10 miles flows through a steep-walled canyon.

While Broad Pass probably affords the most feasible railway route, because it is most direct, there are other low divides leading from the Susitna into the Nenana basin. A gravel-floored flat connects the

---

[1] Railway routes in Alaska (report of Alaska Railroad Commission): H. Doc. No. 1346, 62d Cong., 3d sess., p. [illegible], 1913.

upper Susitna Valley near Valdez Creek with Nenana River. Another low pass lies between the headwaters of Deadman Creek, flowing into the Susitna on the south, and Brushkana Creek, flowing into the Nenana on the north.

VEGETATION AND GAME.

Most of the mapped area is above timber line; that is, more than 2,500 feet above sea level. Vegetation is therefore not so dense as at lower altitudes. A sparse growth of spruce is seen along Susitna River as far north as the glaciers at the heads of its two main forks. A similar growth of spruce covers the broad, flat divide between Susitna River and the Nenana. Spruce of much better quality grows on Butte Creek and near the mouth of Jack River, but the timber on the head of Chulitna River is similar to that on the upper Nenana and the Susitna. The better timber, like that on Butte Creek, is suitable for local mining needs and has been used on Valdez Creek for all purposes since the supply close at hand was exhausted.

In most of the region travelers are dependent on willows or alders for camp use. Good willows can nearly always be found on the smaller streams at elevations between 2,500 and 3,000 or 3,200 feet above sea level. The large willows are rarely found higher than 3,500 feet above the sea. The elevation of about 3,000 feet also affords the best traveling, for brush as well as timber is absent and grass for horse feed is most abundant.

Game is fairly plentiful in most of the region, but would doubtless disappear, as it has in the vicinity of Valdez Creek, if mining or other enterprises should bring in a considerable number of white men. The Indians, of whom there are about 30 at Valdez Creek, live almost entirely on game during a large part of the year and find their best hunting grounds on Jack River and Yanert Fork of Nenana River.

Ptarmigan, caribou, moose, and sheep are the principal game animals. Ptarmigan are abundant in most of the willow thickets above timber line. Caribou may be seen at certain seasons in nearly all parts of the area mapped. Moose appear to be most numerous on the head of Chulitna River and in that vicinity. Sheep are found chiefly in the Alaska Range, particularly on the north side, and are especially plentiful in the mountains about Yanert Fork. Bear also are numerous in this vicinity. Yanert Fork, on the whole, is much the best hunting ground of the region. Grayling and trout are taken from many of the lakes and clear-water streams. Some of the lake trout grow to very large size.

GEOLOGY.

In most of the area mapped on Plate XII unconsolidated morainal deposits and granular igneous rocks such as granite and diorite predominate, yet slate, graywacke, conglomerate, and limestone are widespread.

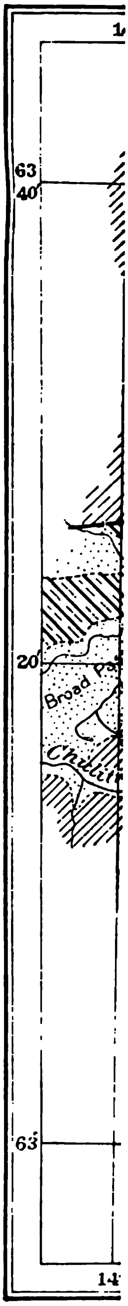
The consolidated sedimentary formations range in age from Devonian to Tertiary. All are folded and metamorphosed but in places show these alterations in little or only moderate degree. In general, the more argillaceous and siliceous rocks range from slate, graywacke, and dense hard conglomerate to crystalline schist. Some of the more highly altered limestone beds are so silicified as to retain little of their original character.

The granular igneous rocks may for field use be designated as granites. They include granite, quartz, diorite, and related rock types and present no unusual features. They are associated in at least one locality with rhyolitic lava flows. More basic igneous rocks, of which the most widespread are basaltic and andesitic lavas, are present in the southeastern part of the region, but are subordinate in amount to the granite and quartz diorite.

The general distribution of consolidated sedimentary and igneous formations in the region (see Pl. XII) is described in the following paragraphs:

Granite and quartz diorite predominate in the mountains south of Nenana River. The basalt mountains south of Butte Creek, the Triassic slate belt north of it, and the Jurassic(?) slate, graywacke, and conglomerate mountains about upper Jack River make up the rest of this area except that occupied by unconsolidated deposits. Granite and diorite occupy a large part of the mountain area between Nenana River and Yanert Fork, but are associated with a variety of sedimentary formations that differ greatly in age and include slate, shale, graywacke, limestone, conglomerate, and schist. Devonian fossils were collected from limestone in a succession of limestone, slate, and conglomerate beds on lower Jack River. At this place the beds form a narrow east-west belt between younger sedimentary formations on the north and south. This narrow belt of Devonian beds comprises all the Paleozoic rocks known in the district. The Devonian formations are succeeded on the east by a group of sedimentary beds, including slate, limestone, graywacke, and schist, that form the mountain mass about the heads of Nenana River and the West Fork of Susitna River. The age of the rocks included in this group is not known but is considered provisionally to be Mesozoic. The higher ridges of the Alaska Range, north of the belt of Devonian and Mesozoic (?) formations is made up of conglomerate, sandstone, shale, slate, graywacke, and schistose equivalents of the same rocks, all belonging to the Cantwell formation (Tertiary). The Cantwell formation was formerly provisionally assigned to the Carboniferous, but was found in the Broad Pass region to carry Eocene plants. This formation is an important structural member of this part of the Alaska Range, having a maximum width of at least 18 miles and extending westward from Cathedral Mountain to Muldrow Glacier.

U. S. GEOLC



One peculiarity of the Cantwell formation is the progressive increase in closeness of folding and intensity of metamorphism from west to east in the area between Nenana River and Cathedral Mountain, where the openly folded, little-altered conglomerate, shale, and sandstone pass into closely folded beds of slate and schist.

All this region has been profoundly glaciated and shows on every side the usual evidences of mountain glaciation, including modified topographic forms, moraines, and glacial lakes.

MINERAL RESOURCES.

The association of intrusive granite and diorite with the slate and limestone formations suggests the possibility of mineralization and the presence of metalliferous deposits, but so far as hasty observation shows the mineralization in the region visited is less than would be expected from a knowledge of the geology. Some of the slate formations, however, are gold bearing. Placer gold in small amount has been found on Butte, Wickersham, and other creeks near by and also on the head of the West Fork of Susitna River. Some copper is present in the lava flows south of Butte Creek, but is not known to be of commercial importance. Coal of commercial value is not known in the district, although it is present in thin beds on the head of Jack River and has been found in thicker beds on Coal Creek, a tributary of Susitna River south of Butte Creek.

Prospecting in the Broad Pass region is difficult on account of the distance from sources of supply and the lack of transportation. The region has not been thoroughly prospected, but it may be said that such work as has been done has not yielded very encouraging results.

MINING IN THE VALDEZ CREEK PLACER DISTRICT.

By Fred H. Moffit.

Valdez Creek is a headwater tributary of Susitna River. It lies about 65 miles west of the Valdez-Fairbanks road and is one of the three known placer-gold districts on the south slopes of the Alaska Range.

Gold was discovered on Valdez Creek in the fall of 1903. The first gold produced was taken from gravel deposits along the stream, but gold was found later in an old buried channel of Valdez Creek that joins the present channel on claim No. 2 above Discovery. The claims along this gravel-filled canyon proved to be some of the most valuable property in the district, although other claims on Valdez Creek and some of its tributaries, notably Lucky Gulch, have been gold producers.

The district was visited by United States Geological Survey parties in 1910, and the progress made in exploiting its gold deposits at that time was described in a paper published the following year.[1] During the three years since 1910 mining has been carried on in the old channel gravel deposits, on one or two of the creek claims near by, and on Lucky Gulch. In addition, assessment work has been performed on many other claims that have not been important gold producers.

Since 1910 the Monahan tunnel in the old canyon gravels has been extended about 500 feet, or from 700 to 1,200 feet, thereby proving that the gold-bearing gravels continue that distance but yielding no evidence to indicate where the east end of the canyon is situated. Bad air made work in the tunnel slow and difficult, yet mining was conducted profitably so long as the work was carried on. The tunnel is now abandoned, the need for it having been ended by the introduction of hydraulic mining.

Since 1910 nearly all the claims on the lower part of Valdez Creek, including the bench claims north of the creek through which the old channel runs, have come under the control of the Valdez Creek Placer Mines Co. This company in 1913 installed a small hydraulic plant

---

[1] Moffit, F. H., The upper Susitna and Chistochina districts: U. S. Geol. Survey Bull. 480, pp. 114-124, 1911. See also Moffit, F. H., Headwater regions of Gulkana and Susitna rivers, Alaska: U. S. Geol. Survey Bull. 498, pp. 53-65, 1912.

and began mining at the lower or west end of the old channel, where the Monahan tunnel begins. Nearly a mile and a quarter of ditch was constructed and a line of pipe was laid to the giant at the working face. With this plant enough of the gravel filling in the old canyon was removed between the first of August and the end of the season to lay bare a small area of bedrock.

This work was preliminary to the installation of a larger plant in 1914. It is planned to replace the small pipe now used by about 4,800 feet of pipe ranging in size from 36 inches at the penstock to 18 inches at the pit and to substitute 6-inch giants for the small ones. This equipment will make available an abundant supply of water under a head of nearly 300 feet. About 100 feet of head is lost under the present arrangement, for the pipe at hand was too short to reach from the giants to the ditch, and the water had to be turned into a depression and picked up again at a lower level. A sawmill will be built and also an electric plant, operated by water from Timberline Creek, to furnish light and power.

The old channel of Valdez Creek is favorably situated for hydraulic mining, there being a good supply of water and an excellent dump for tailings. It is probable, however, that the large number of granite bowlders in the upper part of the gravel deposit will cause considerable trouble.

The well-established winter trail on the ice of Gulkana, Maclaren, and Susitna rivers is still used for carrying freight to Valdez Creek, but the summer trail leaving the Valdez-Fairbanks road at Bear Creek below Gulkana is now practically abandoned in favor of the shorter trail from Paxson.

The gold production of the Valdez Creek district in 1913 was small, coming in large part from Lucky Gulch, for, as has been shown, most of the season was given up on the main stream to what may be called dead work. Probably not over 25 men were engaged in mining in the district at any one time during the summer, but it is expected that this number will be nearly doubled in 1914.

THE CHISANA PLACER DISTRICT.

By Alfred H. Brooks.

INTRODUCTION.

The Chisana placer district, also called the Shushana district, comprises an ill-defined area lying in the headwater region of Chisana River (sometimes known as the Shushana), which joins with the Nabesna to form the Tanana, which in turn flows into the Yukon. The discovery of gold placers in this district in 1913 made it the focal point of interest to miners and prospectors and resulted in a large influx of people from all parts of Alaska, as well as from outside of the Territory. This region has not been visited by any member of the Survey since the finding of the placer gold. Its geology and topography are, however, fairly well known through previous surveys, and much data on the occurrence of the alluvial gold have been obtained from several reliable sources.

While exploring White and Tanana rivers in 1898 W. J. Peters and the writer passed about 40 miles north of the locality at which gold was discovered,[1] and the following year extended this work by an exploration [2] which traversed the headwaters of the Chisana. At about the same time Rohn [3] reached this region by crossing the Wrangell Mountains from the south. More accurate surveys were made in the same field in 1902 [4] by F. C. Schrader and W. C. Mendenhall. The most comprehensive report on this province is that by Moffit, Knopf, and Capps,[5] who in 1908 extended the geologic and topographic mapping of this area.

Since the discovery of placer gold the district has also been visited by D. D. Cairnes, of the Geological Survey of Canada. Mr. Cairnes has kindly furnished the writer both with cartographic data and with an advance copy of a paper [6] containing the results of this

---

[1] Brooks, A. H., A reconnaissance in the White and Tanana river basins, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 425–494, 1900.

[2] Brooks, A. H., A reconnaissance from Pyramid Harbor to Eagle City, Alaska: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 331–391, 1900.

[3] Rohn, Oscar, A reconnaissance of the Chitina River and the Skolai Mountains: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 393–440, 1900.

[4] Mendenhall, W. C., and Schrader, F. C., The mineral resources of the Mount Wrangell district, Alaska: U. S. Geol. Survey Prof. Paper 15, 1903.

[5] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska, with a section on the Quaternary by S. R. Capps: U. S. Geol. Survey Bull. 417, 1910.

[6] Cairnes, D. D., Chisana gold fields: Canadian Min. Inst. Bull. 24, 1914.

examination. The writer is also fortunate in having the use of notes made by A. C. Baldwin, engineer of the International Boundary Commission, who passed through the Chisana district in the fall of 1913, as well as those of A. Neustaedter, a mining engineer, who also recently visited this field. Much information is therefore available concerning the region in which the discovery was made, and it will be summarized here for the use of the prospector. The writer's own field work of many years ago, of course, furnished only a small part of the data here presented.

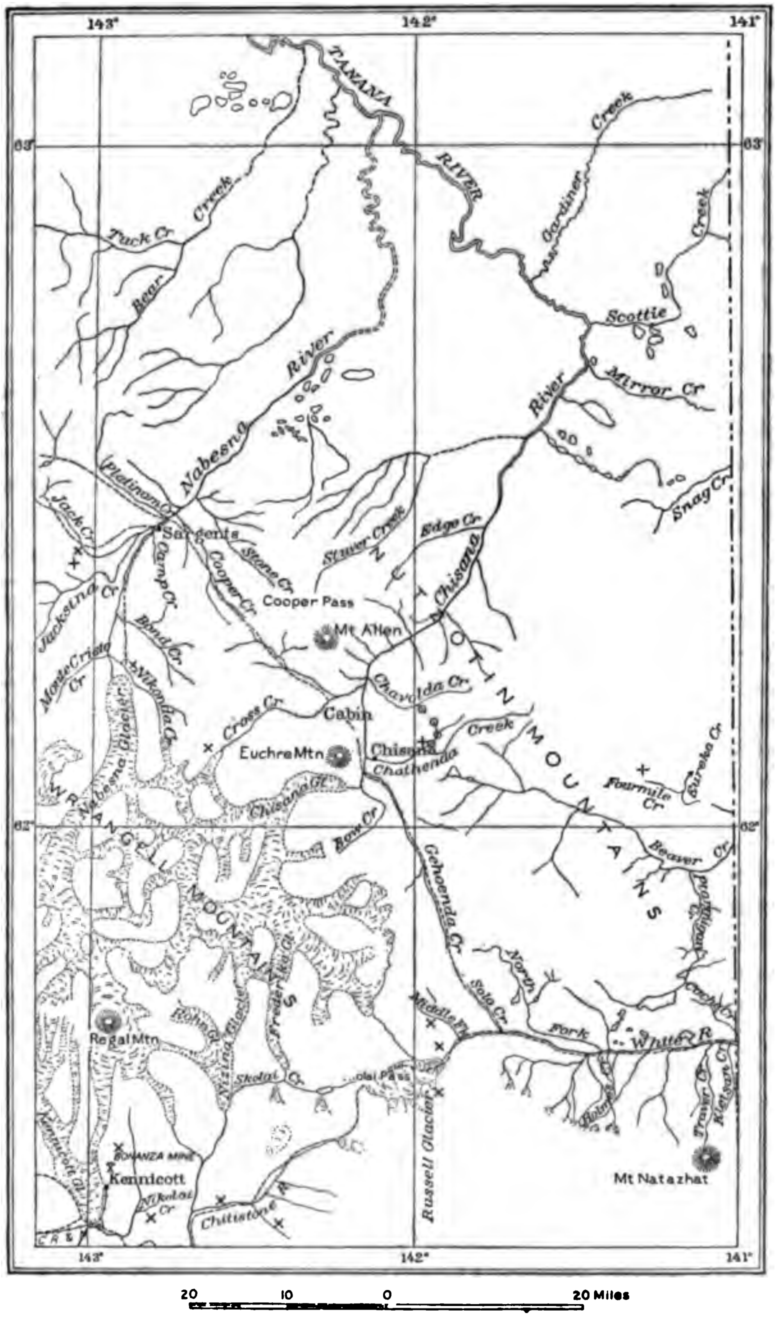
GEOGRAPHY.

Topography.—The site of the placer-gold discovery is centrally located in the quadrangle roughly blocked out by the international boundary on the east, meridian 143° and parallels 61° 30′ and 63°. (See Pl. XIII.) Its southwestern part is occupied by the snow and ice clad Wrangell Mountains, whose highest peaks are over 16,000 feet above sea level. On the north the Wrangell Mountains fall off abruptly to a belt of lesser relief that stretches from White River on the southeast to the head of Copper River on the northwest. Northeast of this depression are the Nutzotin Mountains, a rugged highland area about 20 miles in width, whose peaks stand from 5,000 to 10,000 feet above sea level. These mountains fall off on the northeast to the upper Tanana lowland, a gravel-floored plain about 20 miles in width and about 3,000 feet above sea level. This is bounded on the north by the rolling upland of the Yukon-Tanana region.

To recapitulate, there are in this region five topographic provinces, namely, the Wrangell and Nutzotin mountains, a zone of lesser relief separating the two, the Tanana lowland, and the Yukon-Tanana upland.

Drainage.—The drainage of the region is carried north and east to the Yukon by three large rivers—the White, the Chisana, and the Nabesna. The first springs from Russell Glacier, occupying Skolai Pass, and maintains an easterly direction for some 30 miles, flowing through a broad gravel-filled valley with gentle slope. Near the international boundary it enters a steep-walled valley, from which it emerges 15 miles below, and thence to the Yukon occupies a broad valley.

The Chisana and Nabesna valleys are of the same topographic type. Both rise in glaciers on the northeast flank of Wrangell Mountains. Just below their glacial sources they receive numerous tributaries whose broad valleys form a part of the depression between the Wrangell and Nutzotin mountains. Leaving these basins they enter the Nutzotin Mountains, which they traverse through narrow steep-walled valleys about 20 miles in length and then debouch on the Tanana lowland. These rivers maintain a northwesterly



× Copper + Lode gold ● Placer gold --------- Trail

SKETCH MAP SHOWING MINERAL DEPOSITS OF THE NABESNA, CHISANA, AND WHITE RIVER BASINS.

course across this lowland to the north rim of the valley, where they join to form the Tanana. They are gravel floored throughout their length and flow with tempestuous current.

Climate.—The Chisana region lies in the inland climatic province of Alaska, which is characterized by semiarid conditions, severe winters, and mild, bright summers. In the Wrangell Mountains there is a heavy snowfall, but in the region north of this range the aggregate precipitation is small. Less than 2 feet of snow is reported in the upper White River basin, and the total precipitation for the year is probably less than 10 inches. There are no records, but the rainfall in the upper Chisana and Nabesna basins is probably a little greater than in other parts of the province.

Vegetation.—Timber is rather scant in the district. In the valley bottoms spruce and other varieties of trees are found, the largest of which are 18 to 20 inches in diameter. Timber line is 300 to 500 feet above the floors of the main valleys. Above this there is a stunted growth of willow, which locally is found 1,000 feet above the limit of the spruce. The best timber of the district is in the upper White, Chisana, and Nabesna basins and in the Tanana lowland.

Grass is abundant in many parts of the region. The bars of upper White, Chisana, and Nabesna rivers and the Tanana lowland are especially noted for their forage plants. Unlike most other parts of Alaska, this region furnishes some winter as well as summer pasture. Owing to the dry climate the grass cures on the stalk, and as the light snowfall blows away in favored localities, winter grazing is possible. Horses have been frequently wintered in the region without feeding. It is not known how much of this winter pasturage there is, as only local patches have been utilized.

Game and fish.—While some forms of agriculture are undoubtedly possible in this region, so far the only source of food has been the game and fish. The large game includes sheep, abundant in the mountains; moose, not very plentiful; and caribou, which in some years are present in considerable numbers. Large brown bears, probably grizzlies, as well as black bears are found in the region, and there are many smaller fur-bearing animals. Ptarmigan are seen above timber line and grouse in the lowlands. The Tanana flats are breeding grounds for geese, ducks, and other water fowl. Salmon do not reach the region, but grayling, or arctic trout, are abundant in the clear-water streams, and the lakes contain a species of whitefish.

GEOLOGY.

Sedimentary and volcanic rocks.—The oldest rocks of this province are phyllites, impure limestones, mica schists, and gneissoid granites such as make up the highlands north of the Tanana lowland. The metamorphic series is to be correlated with the Birch Creek schist of the Yukon-Tanana region, believed to be of Cambrian or pre-Cambrian age. With these are associated some greenstone schists that are probably younger than the other crystalline rocks.

Overlying these are heavy conglomerates and slates that are probably of Devonian age. These rocks were found in a series of isolated hills that rise out of the gravel flat connecting the upper Tanana lowland with the middle White River valley. The north front of the Wrangell Mountains is made up of slates, volcanic rocks, and massive limestones that contain Carboniferous fossils. The relation of these to the conglomerates and slates (Devonian) above described has not been determined, as the two series are 30 or 40 miles apart.

A profound fault is believed to separate these Carboniferous rocks from the formations that make up the Nutzotin Mountains, which are composed of slates and graywackes, with some beds of fine conglomerate and a little limestone. These rocks are of Mesozoic age, probably chiefly Lower Cretaceous and Jurassic, but include some Triassic limestones and slates. They probably also occur above the Carboniferous on the Wrangell Mountains but have not there been definitely recognized. The most abundant Tertiary formation is the great complex of lavas that makes up the Wrangell Mountains, whose northern margin reaches into the district here discussed. Some sandstones have been found in the Tanana Valley below the Nabesna, and these are probably Tertiary. These sandstones have not been found in the region here discussed, but coal has been found in the upper White River basin near the international boundary and is probably of Tertiary age; the Tanana lowland may perhaps be carved out of rocks of this formation.

Igneous intrusives.—Igneous intrusives are not uncommon in the region. Most of those occurring in the larger masses are dioritic. Some are granitic. Rocks that have a general lithologic similarity to these but are porphyritic in texture also occur in dikes throughout much of the region. These intrusives are widely distributed and probably belong to one general period of intrusion, which is believed to be Mesozoic. In addition to these there are probably older granitic intrusives, now represented by gneissic rock, in the region lying north of the Tanana lowland. Diabase dikes also occur in some parts of the area and are probably of Tertiary age.

Structure.—All the terranes described above have a general northwest-southeast strike. The metamorphic rocks have been intensely squeezed and sheared, their planes of foliation dipping generally to the north. It is probable that the structure of the Nutzotin Mountains is synclinal, as older rocks are found both north and south of the range. The detailed structure of these mountains is, however, complex, and both strikes and dips vary from place to place. It has already been noted that the Nutzotin Mountains and Wrangell Mountains are probably separated by a profound fault. On the southwest side of this fault the rocks usually dip to southwest, and the evidence in hand indicates that the structure of the Wrangell Mountains also is synclinal.

Unconsolidated deposits.—All the larger river valleys are deeply filled with silts, sands, and gravels. This blanket of unconsolidated material extends in some places far up the hill slopes. On White River, for example, it occurs 600 feet above the valley bottom, and it is found on the divides between White and Chisana rivers 1,200 feet above the valley bottoms.

Most of the material is directly or indirectly the result of glacial action. The larger rivers and many of the small streams head in glaciers, which are continually contributing débris that is carried away by the streams and deposited below. These glaciers formerly extended farther down the valleys than they do now. White River valley was once filled with ice far below the international boundary, and the valleys of the Chisana and Nabesna were filled to the northern front of the Nutzotin Mountains. Gravels and sands were deposited along the margins of these glaciers, and finer material was deposited in front, as outwash deposits, especially during the recession of the ice, which was accompanied by flooding of the water courses. In addition to these water-laid deposits, ice-borne material also was laid down by glaciers and is now found in some localities in the form of bowlder clay. Most of the unconsolidated material of the district is therefore directly or indirectly of glacial origin. The possibility of finding preglacial gravels is considered under the discussion of placers (p. 317).

A deposit of white tuff that occurs immediately underneath the soil is one of the most striking formations of the district. It is found in huge drifts in the Copper-White River basin and as a white bed in other parts of the area. This is part of an eruption of a volcano whose ejecta fell over an area of more than 20,000 square miles in the upper Yukon basin. According to Thomas Riggs, jr., engineer of the International Boundary Commission, the source of this tuff is a small crater near the international boundary, not far from the front of St. Elias Range.

Heavy beds of peat occur in the upper White River basin. In one section several beds of peat were observed separated by layers of fine sand or silt.

GOLD DEPOSITS.

History of discovery.—The exploration of the Tanana in 1898 led the writer to form the opinion that the metamorphic rocks north of the lowland had been mineralized, as indicated by the following quotation:[1]

> Near the mouth of Scottie Creek, on the Tanana, is an exposure of impure limestone schist and mica schist. The rock has been much deformed, and quartz veins are numerous. The mineral-bearing solutions have been injected in a zone of shearing some 30 feet wide, in which lie numerous mineralized quartz veins. Copper and iron pyrite were observed, and probably some galena. In a specimen of the calcareous schist taken from close to the shear zone, but not forming part of it, I found some grains of gold which had evidently been brought in by the penetrating solution. The gold occurs in the unaltered rock and was not associated with any extraneous matter.
>
> At another locality, about 15 miles below the mouth of the Robertson River, on the north side of the Tanana, a mineralized shear zone was found in the granite. This zone was not over 10 feet wide, and the granite along it had been brecciated rather than deformed. In this zone pyrite was observed and a few fine particles of gold.

During the hurried traverse of the Nutzotin Mountains made in the following year indications of some local auriferous mineralization were seen, but no very encouraging evidence of the presence of gold was found. It remained for Schrader in 1902 to offer more definite proof of the presence of auriferous quartz. His report is quoted as follows:[2]

> On the Chisana no gold was found above the Nutzotin Mountains. The Mesozoic rocks of the Nutzotin Range, however, consisting of slates, schists, greywackes, shales, limestones, and conglomerates, beyond doubt contain some gold. In these rocks one would expect the quartz, which occurs either as veinlets or stringers along the bights of folds or in the crushed material along faults and shear zones, to be the most favorable place to look for gold. An assay of a sample of quartz collected in a shear zone at the head of the canyon on the west side of the river gave a trace of gold. From a similar occurrence of quartz and calcite in crumpled shistose limestone and slate on Mound Creek a specimen was collected for assay. The returns gave 0.03 ounce of gold and a trace of silver, a money value of 60 cents per ton.

When in 1908 Moffit and Knopf visited the region they found that some auriferous quartz veins had been located, and the results of their studies are summarized by them as follows:[3]

> From the descriptions given in the preceding pages, it will be apparent that a lode-quartz region of some promise has been discovered in the Nutzotin Mountains near the international boundary and that as yet it has been but imperfectly explored by the prospector. It has been shown that the intrusion of quartz diorite produced a number of contact-metamorphic bodies of copper sulphides, and the occurrence on Jacksina Creek suggests that the magma was also capable of effecting an auriferous mineralization. From the meager data at hand it is perhaps unsafe to venture on

---

[1] Brooks, A. H., A reconnaissance in the White and Tanana river basins, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 486–487, 1900.

[2] Mendenhall, W. C., and Schrader, F. C., The mineral resources of the Mount Wrangell district, Alaska: U. S. Geol. Survey Prof. Paper 15, p. 45, 1903.

[3] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska, with a section on the Quaternary by S. R. Capps: U. S. Geol. Survey Bull. 417, p. 62, 1910.

generalizations, yet it is probable that the quartz veins are genetically related to the intrusion of the post-Carboniferous quartz diorites and that therefore the intruded areas are those most likely to be mineral bearing. Such areas are known to occur throughout the Nutzotin Mountains at a number of localities, especially along their northeastern flanks. Brooks has mapped a large area of granular intrusive on the lower Nabesna. It is probable that in the vicinity of such masses the search for lode quartz may be prosecuted with the most hope of success.

Though copper deposits have been known in this district since 1899 and gold since 1902 neither have been much developed. Assessment work has been kept up and some developments have been made on both copper and gold lode claims, but the inaccessibility of the region has discouraged all but a few miners. Probably not over an average of 25 men were in the entire region until the placer gold was discovered. Some search was made for gold placers and several prospects were found, but there was no productive mining. A number of years ago a little sluicing was done near the scene of the recent discovery, but without encouraging results.

William E. James and Peter Nelson are credited with having found the first workable placer. This discovery, which took place on May 3, 1913, was made on a creek called Bonanza by the prospectors, but more important was the find made on a small tributary of the stream named Little Eldorado. Gold was also found in the gravels of other near-by streams, but mining in 1913 was largely confined to Little Eldorado.

Geographic nomenclature.—In accordance with the prevailing practice, the prospectors in this district promptly applied new names to every watercourse on which claims were staked, giving no heed to the fact that 10 years before this influx of miners an official and accurate map of the district had been published on which every effort had been made to apply the correct Indian nomenclature to these streams. These authorized names were entirely ignored by the prospectors; Chatenda Creek became Johnson Creek, Chapolda Creek became Wilson Creek, and a new crop of Bonanza, Eldorado, Glacier, Coarse Gold, and Goldbottom creeks were started—names that have been used scores of times and that appear in every placer district of Alaska. It is unworthy of Alaska pioneers to substitute this commonplace terminology for the euphonious native names, and especially to persist in the foolish duplication of geographic place names. Concerted effort should be made by Alaskans to put a stop to this thoughtless practice, which leads to hopeless confusion.

Unfortunately these prospectors' names can not be ignored, for they are used in recording claims and thus form a part of the court records. Names of the watercourses have been changed by prospectors as follows: Chisana River to Shushana River, Gehoenda Creek to Trail Creek, Chatenda Creek to Johnson Creek, and Chapolda

Creek to Wilson Creek. Other names also have probably been changed, but of these there is as yet no record.

Placers.—Auriferous gravels have been found in an area about 5 by 8 miles square lying east of and tributary to the upper Chisana (Pl. XIV), but from what is known of the geology of the region there is no inherent reason why the gold-bearing area should be so limited. This area is drained by Chatenda (Johnson) and Chapolda (Wilson) creeks. The headwaters of these streams include rather broad open basins, but in their lower courses they flow through narrow, steep-walled canyons. Only their lower courses are timbered, their upper basins, where the actual mining has been done, being far above the limit of timber.

The bedrock of the district is chiefly closely folded gray and black shale with some intercalated beds of sandstone and conglomerate. Some of the shales are calcareous. Intrusive rocks occurring in dikes are abundant. These formations are similar to those that make up much of the Nutzotin Mountains and are presumably Mesozoic in age.

In view of the presence of auriferous quartz veins in the district there can be little doubt as to the source of the placer gold. One such mineralized quartz vein, which has long been known, lies close to the mouth of Bonanza Creek and therefore near the scene of the first gold discovery. The auriferous mineralization is doubtless connected with the intrusion of the igneous rocks (p. 312). The gravels that were mined in the summer of 1913 will not exceed 4 feet in depth and the pay streak on Little Eldorado is reported [1] to be about 100 feet wide. These shallow gravels are not moss covered and are therefore not permanently frozen.

During the summer of 1913 the Discovery claim, on Little Eldorado Creek, was opened and was the principal source of the gold output of the district. Some mining was also done on near-by claims, and placer gold was found on several other creeks in the Chatenda and Chapolda basins.[2] The total placer-gold production in 1913 is variously estimated, the values given ranging from $30,000 to $70,000.

Cairnes [3] has described the character of the placer gold as follows:

> The gold itself from Chisana that has been assayed is worth about $16.10 per ounce, and is dark in color, having a peculiar almost bronzelike cast, due possibly to a slight coating of iron oxide. All that has so far been found is also quite coarse, practically no dust having been obtained. The greater amount of the gold is in particles ranging in value from 1 to 10 cents; but nuggets worth from $1 to $2 are common, and some have been found worth from $18 to $20, or even more. In shape, the gold

---

[1] Cairnes, D. D., Chisana gold fields: Canadian Min. Inst. Bull. 24, p. 61, 1914.

[2] Recent reports indicate that gold placers have been found on Big Skookam, Dahl, Rhyolite Canyon, Gold Run, Big Eldorado, and Dry creeks. A high gold tenor is reported in the gravels at a number of new localities, and the outlook for a fairly large gold output in 1914 seems favorable.

[3] Op. cit., p. 62.

particles are dominantly flat, some being decidedly thin and flakelike, indicating apparently that the gold was prevailingly deposited originally either in narrow seams in the inclosing slate rock or along the contact between quartz veinlets and the inclosing rock formations.

Future of placer mining.—It will be evident that the shallow gravels, occupying narrow valley floors, can not contain any large amount of auriferous alluvium. The conditions adverse to mining are lack of timber and, in many of the creeks, scarcity of water, conditions that are partly offset by the absence of any overburden and the thawed condition of the gravels. The evidence in hand indicates that the richer placers can be mined at a profit in spite of the present high cost of operating. On the other hand, the discoveries thus far made have not revealed a sufficient bulk of material to assure a large placer camp. There are some deep gravels on Chapolda, Chatenda, and other creeks of this district, but these have not been prospected. Some attempts to reach bedrock during the winter of 1912–13 were said to be unsuccessful because flowing water was encountered, and if this is common underground mining is not likely to be feasible, and any gold in the deep gravels will have to be recovered by open cuts.

There are some gravel-covered benches in this district, said to carry gold, but they have not been sufficiently opened up to test their value. In its general features this district is comparable to the Chistochina, which has produced about $1,700,000 worth of gold since mining began, in 1899.

The evidence in hand indicates that mineralization in the district is widespread, and placer prospects have been found both northwest and southeast of the scene of the actual mining. Now that the prospectors are in this field other discoveries can be expected, and there is no reason to believe that auriferous gravels may not occur in other parts of the region.

The fact that the region adjacent to the discovery is glaciated is unfavorable for the occurrence of large bodies of workable placers. The glaciers have swept away and dissipated nearly all the accumulations of preglacial auriferous gravels, and since the period of glacial action the time has not been long enough to permit any large accumulations. Some preglacial channels may, however, be preserved, and these would seem to be the best sites for extensive placer deposits. The presence or absence of such channels can be established only by detailed prospecting.

The northern fronts of the glaciers that occupied the Chisana Valley reached only the north margin of the Tanana lowland. This can therefore be considered the approximate northern limit of glaciation, beyond which the preglacial gravels have not been disturbed by ice action. Ice erosion gradually decreased toward the limit of glaciation, so that prospectors approaching this area from the south should find increasing possibility of discovering undisturbed preglacial gravels until they reach the line of the old ice front.

Another field worthy of investigation for placer gold and adjacent to the scene of the discovery is the highlands north of the Tanana lowlands. This includes the basins of Scottie, Gardiner, and other creeks flowing from the north. Here, so far as known, the rock formations are in part the same as those of the placer camps of the Yukon-Tanana region. Moreover, as already pointed out (p. 314), evidence of auriferous mineralization has been observed in this field. A few prospectors have roamed over this region, but most of them have been without sufficient supplies to permit them to test the gravels thoroughly, though colors of gold have been found. The gravels in this area are probably deep, how deep no one can foretell. It may become necessary to sink prospecting shafts, which in a region so remote from transportation routes will be expensive. If there are gold deposits here they are probably associated with intrusive granites or diorites, as in other parts of the Yukon-Tanana region, and the prospector should therefore seek such granite intrusives and, finding them, give special attention to streams that flow across the contacts of the igneous rocks and the schists in which these rocks have been injected.

COPPER.

It is not the purpose of this report to discuss in detail the copper deposits of the region, which have been fully described in the publications already cited. The placer copper of the upper White River has long been known and utilized by the natives. It was first visited by white men in 1891, when C. W. Hayes, then of the Geological Survey, made a brief examination of the occurrence.[1] In 1899 copper was first found in bedrock.[2] Since that time many copper-bearing lodes have been found and some developments made. No productive copper mining can be expected till railroad communication with the coast is established.

The copper occurs (1) in association with ancient volcanics and (2) in contact-metamorphic limestones and intrusive diorites. Both classes of rocks are typically developed along the northern flank of the Wrangell Mountains and are presumably of Carboniferous age. The copper-bearing minerals are sulphides and native copper. Native copper occurs both as a primary constituent of amygdaloidal lava and as a secondary oxidation product of sulphides.

---

[1] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, pp. 117-162, 1892.

[2] Brooks A. H., A reconnaissance from Pyramid Harbor to Eagle City, Alaska: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 380-381, 1900.

MEANS OF COMMUNICATION.

The Chisana placer district may be approached by feasible routes of travel from nearly every direction. The shortest route from an established transportation system leads from McCarthy, a station on the Copper River & Northwestern Railway, 191 miles from Cordova, over the ice-covered Skolai Pass to White River and thence across a second divide to the Chisana. This distance is about 100 miles. The journey necessitates crossing the Russell Glacier, a passage involving both difficulty and danger. It is available, however, for horses. Another route that has been used extends through the Wrangell Mountains by way of Nizina and Chisana glaciers. By this route the distance from McCarthy to Chisana is about 80 miles. It involves crossing glacial ice for some 40 miles, as well as a divide some 11,000 feet high, and is not available for horses. Glacial ice can be entirely avoided by the Valdez or Chitina route, which leaves the railroad at Chitina, 131 miles from Cordova, or the coast at Valdez, and follows a wagon road to Gulkana, 80 miles from Chitina and 128 miles from Valdez. From Gulkana it follows a horse trail to Batzulnetas, near the head of Copper River, thence crosses a divide to Nabesna River and a second divide to the Chisana. The distance from Gulkana to Chisana by this route is about 140 miles, making a total of about 220 miles to Chitina and 268 miles to Valdez.

Small steamers have ascended the Tanana as far as the mouth of the Nabesna, but navigation is difficult, as the current is swift and there are many bars and snags. At low water navigation may not be feasible. The mouth of the Nabesna is about 250 miles by river from Fairbanks and 70 miles by trail from the Chisana district. The old mail trail which leads from Eagle on the Yukon to Tanana Crossing can also be used. By this trail it is about 150 miles to Tanana Crossing and thence about 90 miles to the Chisana district.

There are also two principal routes of access from Canadian territory. A wagon road leads from Whitehorse—the end of the railroad on the White Pass & Yukon Route, 110 miles from Skagway—to Lake Kluane, the distance being 143 miles. Thence there is a trail to Chisana by way of White River, the distance being about 225 miles. The White River route is described by Cairnes [1] as follows:

> The White River route follows up White River from its mouth to Beaver Creek, a distance which is generally considered to be about 115 miles but which according to a survey of the river made by W. J. Peters in 1898 is only 85 miles. Ordinary light-draft steam and gasoline river boats may be navigated for about 60 to 70 miles up White River, or to about the mouth of Donjek River; and one small specially designed gasoline boat succeeded in reaching the mouth of Beaver Creek [also called Snag

---

[1] Cairnes, D. D., Chisana gold fields: Canadian Min. Inst. Bull. 24, 1914.

River] and is reported to have made the passage from the mouth of the White to Beaver Creek in four days. Poling boats have in the past been mainly utilized on White River from the mouth up, and last season were in use especially above the mouth of Donjek River, or above the different points at which the power boats were inoperative. It is claimed also that it is quite possible to take poling boats a considerable distance up Beaver Creek.

INDUSTRIAL CONDITIONS.

The news of the finding of placer gold in the Chisana district was quickly disseminated and widely advertised by those who expected to reap a profit directly or indirectly from the expected gold seekers. It came at a time when placer mining was at a rather low ebb in many of the older districts and thus found many who were anxious to find a new field of activity. As a consequence several thousand gold seekers, both from Alaska and from outside of the Territory, started for the scene of discovery, and as the various routes presented no serious physical obstacles to travel, most of these reached their destination. Many were but ill equipped for a sojourn in a region so distant from points of supply and almost at once had to turn back for lack of provisions. There was the usual disappointment, for long before the main mass of stampeders had reached the new diggings every creek in the district had been covered with claim locations. The recent change in the placer mining law, however, prevented the wholesale preemption of the entire district by a few persons, a practice so frequent under the old statute.

Nearly 100 cabins were built on lower Chatenda (Johnson) Creek, forming "Chisana City," which became the distributing point for the district. It is stated that about 300 men wintered in the district. As has already been stated, the gravels do not seem to be favorable to underground mining, hence probably no great amount of prospecting was accomplished in the winter. The coming summer will undoubtedly witness more thorough prospecting of the known placers and a further search for other gold-bearing areas.

LODE MINING NEAR FAIRBANKS.

By Theodore Chapin.

INTRODUCTION.

The occurrence of auriferous quartz veins in the vicinity of Fairbanks has been known for a number of years, but until recently quartz mining has received relatively little attention. In the last four or five years, however, considerable interest has been taken in lode prospecting. A number of producing mines are in operation and many prospects are now being opened.

The total lode production for the Fairbanks district is about $674,000. In 1911 the production was $64,100,[1] and about $60,000 had been produced previously. About $200,000 was produced in 1912. The estimate of the value of the gold-lode production in 1913, based on incomplete returns, places it at $350,000.

In 1913 the writer spent a few days in the Fairbanks district to study the occurrence of lodes and to gather data regarding recent developments. Field work began August 10 and closed August 31. The work was planned to supplement the investigations of Philip S. Smith in 1912[2] and was facilitated by his previous studies. A number of the sketch maps are taken from Smith's report, with additions and corrections made necessary by recent developments.

PRESENT CONDITIONS.

The production for 1913, which was nearly double that of the previous year, in a measure reflects the progress made in quartz mining, which showed a marked advancement, particularly in development of lodes, in spite of the fact that fewer lodes were being developed and fewer men prospecting than in 1912. The rush of men to the Chisana took from Fairbanks a number of men who otherwise would have been working or prospecting for quartz lodes.

Ten plants have reached a producing stage and maintain mills of their own. Others produce considerable ore and ship it to near-by mills for treatment. Several new mills are contemplated and should be in operation before the close of the open season of 1914. Six

---

[1] U. S. Geol. Survey Bull. 520, p. 30, 1912.

[2] Smith, P. S., Lode mining near Fairbanks: U. S. Geol. Survey Bull. 542, pp. 137-202, 1913.

Hendy mills in operation in this district have a total of 23 stamps of 1,000 pounds each. There are also two Nissen mills, one 10-stamp Straub mill, one Little Giant crusher, and three small mills of local manufacture used for prospecting.

With one exception all the mills of the district use wood for fuel. As the local supply is becoming depleted the price is advancing, and at present as high as $17.50 a cord is paid for 16-foot logs, which, when cut into cord-wood lengths, make only about two-thirds of a cord, so that in reality wood for fuel costs over $25 a cord. At several mills the operators rather than pay this price burn stumps. At one mine alone $20,000 a year is paid for wood used for fuel and mine timbering. A reduction on fuel costs alone would make many lodes workable which at present can not be successfully operated. One mill is run by gasoline power. No figures are available to show the comparative cost of this and the wood-burning plants, as it has been in operation for only a short time.

The stimulating effect of the proposed railroad from tidewater to the interior of Alaska has already been felt. Its actual operation should greatly reduce mining expenses.

GENERAL GEOLOGY.

The following notes on the geology of the Fairbanks district are abstracted from a report by Prindle and Katz:[1]

The prevailing bedrock of the Fairbanks district is the Birch Creek schist, a series of highly metamorphosed siliceous sediments consisting of massive quartzites, quartzite schists, quartz-mica schists, hornblende schists in part amphibolitic, carbonaceous schists, crystalline limestone, altered calcareous rocks, with associated eclogitic rocks, andalusite hornfels, and a small amount of granitic gneiss derived from intrusive porphyritic granite. These rocks rest on gneissoid intrusive masses. The Birch Creek schist and included intrusive rocks inclose all the lode deposits. The beds of the Birch Creek schist are closely folded, with minor recumbent folds overturned toward the northwest. The general strike is northeast.

The igneous rocks of the Fairbanks district include several varieties of intrusive granular rocks—quartz diorite, porphyritic biotite granite, light-colored persilicic granitic dikes, and altered porphyritic dikes related to granitic and dioritic rocks. Small masses of basalt are also present.

The Birch Creek schist is regarded as probably of pre-Ordovician age. No evidence is at hand in the Fairbanks district to fix definitely the age of the intrusions. Metamorphosed porphyritic granites are thought to belong to a period of intrusion which antedates the meta-

---

[1] [illegible]ndle, L. M., and Katz, F. J., Detailed description of the Fairbanks district: U. S. Geol. Survey Bull. [illegible] 59-131, 1913.

morphism of the region and to be synchronous with similar intrusive gneisses. The unmetamorphosed igneous intrusions are assigned by Prindle to the close of the Mesozoic.

ECONOMIC GEOLOGY.

GOLD DEPOSITS.

The principal gold-bearing lodes of the Fairbanks district (see Pl. XV) are fissure veins and stringer lodes. Of these the fissure veins have proved to be the principal producers of the district. The stringer lodes are composed of noncontinuous lenses and anastomosing stringers of quartz that include lenses of gouge and decomposed country rock, all more or less mineralized.

In some of the veins metallic sulphides are absent or present only in small quantities. Others contain in varying amounts the sulphides of antimony, arsenic, iron, zinc, lead, and bismuth. The sulphide-bearing veins can not easily be further subdivided according to the prevailing sulphide present, as in general one sulphide does not occur to the exclusion of the others. In one lode, however, the association of bismuth minerals and tellurium, together with the absence of other sulphides, seems to mark a distinct type. (See p. 330.)

The gold quartz lodes vary considerably in size. The fissure veins reach a maximum thickness of 15 feet, and the stringer lodes are known to be over 50 feet wide. The productive fissure veins are about 6 inches to 3 feet wide. In a small area or zone there may be a dominant strike to which most of the lodes conform, but no such condition appears to extend over the entire Fairbanks gold-lode region.

In some of the fissure veins the gold is rather evenly distributed throughout the lode. In others it is localized in ore shoots of more or less definite outline. The ore shoot can not usually be told from the leaner part of the vein except by careful sampling of the rock, for in appearance the two are identical. No change in the mineral content is apparent in passing from the ore shoot to the poorer part of the vein, but for some reason the deposition of gold was more or less confined to certain parts of the vein. One horizontal ore shoot is bounded by a fault plane, but nowhere else was it evident that the formation of the ore shoot was controlled by any structural feature. At one mine two parallel ore shoots are horizontal. Others are inclined, one pitching as steeply as 45°.

The oxidized surface portions of the veins have been enriched through residual concentration by broken-down sulphides and portions of the quartz vein removed in the process of weathering. Below the oxidized surface is a zone in which the vein has not been thus enriched and probably is fairly uniform in composition for a considerable depth. Below the enriched surface zone no impoverishment in depth has been noted in the 300 feet to which mining has been carried below the surface, nor is it likely to be found at the depths which will be reached in the near future.

SILVER-LEAD DEPOSITS.

The silver-lead deposits have not become important producers, and at present none of them are opened enough to justify conclusions regarding their possible value. The known lodes of this type are composed of lead sulphide, lead sulphantimonite, and quartz. They occur as nonpersistent flat-lying bodies conforming to the foliation of the schist and appear to be replacements of calcareous bands. These deposits contain silver in notable amounts and may become of economic value if large bodies of ore are found.

MINERALOGY OF THE LODES.

The principal vein material and gangue is quartz. With it are small amounts of albite and orthoclase and associated kaolin and sericite. Calcite holds a subordinate place as a vein mineral but has been noted here and there.

Native gold is widespread and may be seen readily in specimens from any producing lode. It occurs in small crystalline aggregates and flakes embedded in both quartz and metallic sulphides. Besides the visible gold a considerable amount occurs in combination with other elements or so finely divided as to be invisible. Silver is less abundant than gold, but is present in varying amounts in nearly all the gold-bearing lodes, although its minerals are seldom recognized. Tetrahedrite occurs on Dome Creek.[1] Locally silver is found in considerable amounts in association with galena and other lead minerals.

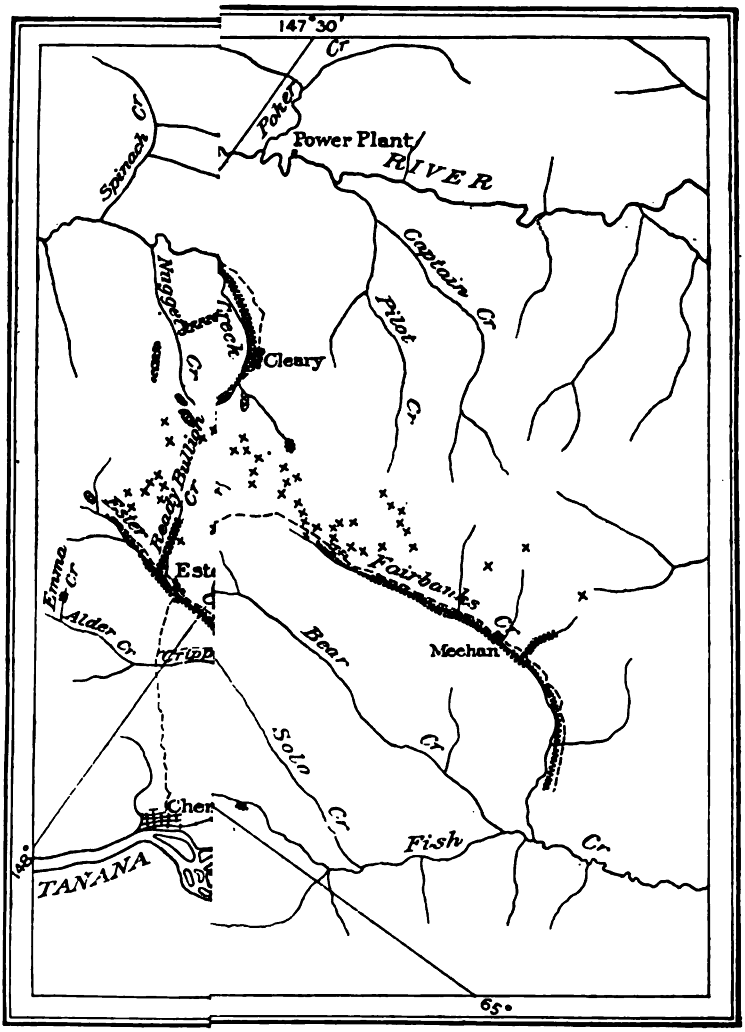
A number of metallic sulphides occur with the quartz. Of these stibnite is the most abundant. It occurs as acicular crystals and as both fine-grained and massive aggregates in the quartz veins. It contains a notable amount of gold.

Other sulphides associated with stibnite in considerable amounts are pyrite and arsenopyrite. The arsenopyrite resembles stibnite, but may be easily distinguished by its superior hardness. It occurs as isolated crystals and intergrown with pyrite in veins and irregular masses several inches thick.

Galena is associated with other sulphides in the gold-quartz veins and as replacement deposits in schist. It carries silver in varying amounts. Another mineral which forms a similar deposit is a sulphantimonite of lead, possibly jamesonite. Sphalerite is sparingly found in a number of places.

---

[1] Smith, P. S., op. cit., p. 179.



By L. M. Prindle, F. J. Katz, P. S. Smith, and Theodore Chapin

On Melba Creek native bismuth and bismuthinite (bismuth sulphide) occur in very rich gold-bearing vein quartz. Specimens of this rock tested in the laboratory of the Geological Survey showed the presence of considerable tellurium, but its mineral association was not determined.

A few crystals of primary chalcocite and derived carbonates were seen in gold-bearing quartz veins at the Homestake mine.

A number of other secondary minerals are present. Scorodite (ferric arsenate) has formed from the alteration of pyrite and arsenopyrite. It occurs as bluish-green veinlets and as massive aggregates. Associated with the lead sulphantimonite and evidently derived from its alteration is a small amount of bindheimite (hydrous antimonate of lead). It occurs as honey-yellow incrustations of fibrous crystals. Pyromorphite (lead phosphate) and cerusite (lead carbonate) were seen at one locality in very small amounts. They occur with galena and are evidently derived by its alteration.

The alteration of stibnite has resulted in several oxides. The most common of these is cervantite, a canary-yellow mineral which occurs as pseudomorphs after acicular crystals of stibnite and also as earthy incrustations and veinlets. The yellow-green stain characteristic of the weathered portion of stibnite-bearing quartz veins is in large part due to this mineral. Stibiconite, a hydrous antimony oxide, is less abundant than cervantite. Besides the minerals noted there are various other alteration products, evidently derived from the stibnite and possibly from other sulphides. Limonitic material is plentiful. It is derived in part from the alteration of pyrite. At the Hudson mine, on Ester Creek, a coating of manganese oxide occurs on vugs in quartz veins.

Cassiterite, wolframite, hematite, and titaniferous iron ore are found in the concentrates from the placers of the Fairbanks region. Evidently their bedrock source was veins in this locality.

MINERALIZATION.

Prindle[1] considers that the mineralization bears a close relation to the intrusion of igneous rocks and that the sequence of events was as follows:

> At about the close of intrusive activity, after the intrusion of dikes of granite porphyry and of persilicic granitic dikes with related veins containing a small proportion of alkali feldspar like that of the persilicic granitic dikes, there was an introduction of further products of intrusive activity in the form of solutions, in part auriferous. Through the activity of these solutions some of the dikes were sericitized, with a little alteration of iron pyrite to iron carbonate, and gold and sulphides were deposited. The occurrence of tourmaline in close association with iron pyrite and arsenopyrite at one locality seems to show one phase of the process. The facts indi-

---

[1] Prindle, L. M., op. cit., pp. 91-92.

cate a close relation between the gold and the sulphides and the reference of both to a genetic relationship with the igneous rocks.

But, as has been pointed out by Prindle, it does not necessarily follow that the areas near the exposures of igneous rocks are the places where lodes are most likely to be found, for it is probable that deformation at the time of intrusion facilitates the transportation of material from the magma, and conditions favorable for solution may be maintained so long that gold derived from this source is carried in solution far into the surrounding rocks before reaching areas where conditions favorable for deposition prevail. Moreover, areas where no outcrops of igneous rocks occur may nevertheless be underlain by such rocks, which are mantled by a thin covering of schist.

The metallization is thus regarded by Prindle as occurring near the end of the Mesozoic era. As has been suggested, however, there appears to be no evidence that it was not in part, at least, early Tertiary.

LODE MINES AND PROSPECTS.

FAIRBANKS CREEK VALLEY.

EAST OF MOOSE CREEK.

Between the forks of Alder Creek at an elevation of about 2,100 feet is the McCarthy claim (see fig. 4), located on a vertical vein of quartz 12 to 15 feet in width. The vein, which strikes about N. 40° E., has been opened by a tunnel for 160 feet, and a number of crosscuts have been made across the vein to determine its extent. The vein material is opaque quartz with large horses of schist. The vein is fractured and refilled in places, but apparently there has been little sulphide mineralization. Assessment work has been done each year, but no work was in progress at the time of visit in 1913.

On the ridge between Alder and Crane creeks, at an elevation of 1,950 feet, a quartz vein is being prospected on the Queen claim. The present developments consist of a short shaft and a 100-foot incline. About 30 feet from the top of the incline the vein is 18 inches wide, but at this place the vein is cut off by a fault striking N. 70° W. and dipping 33° NE., which cuts the vein at a low angle, so this is probably not the full width of the ore body. The incline follows this fault, which evidently was mistaken for the footwall of the vein. The lower portion of the incline was inaccessible, but it is reported that the vein was followed for a distance of 100 feet. The property consists of this and several adjoining claims extending from Alder Creek to a point near the mouth of Crane Creek. No work was in progress at the time of visit, but operations were being planned by the owners for the coming winter.

MOOSE CREEK.

Considerable work had been done on Moose Creek, principally by Crites & Feldman, who have developed their property to a producing stage. The main development work consists of a tunnel 450 feet long, which has been driven along the main vein in a northwesterly direction. At a point 350 feet from the mouth of the tunnel the

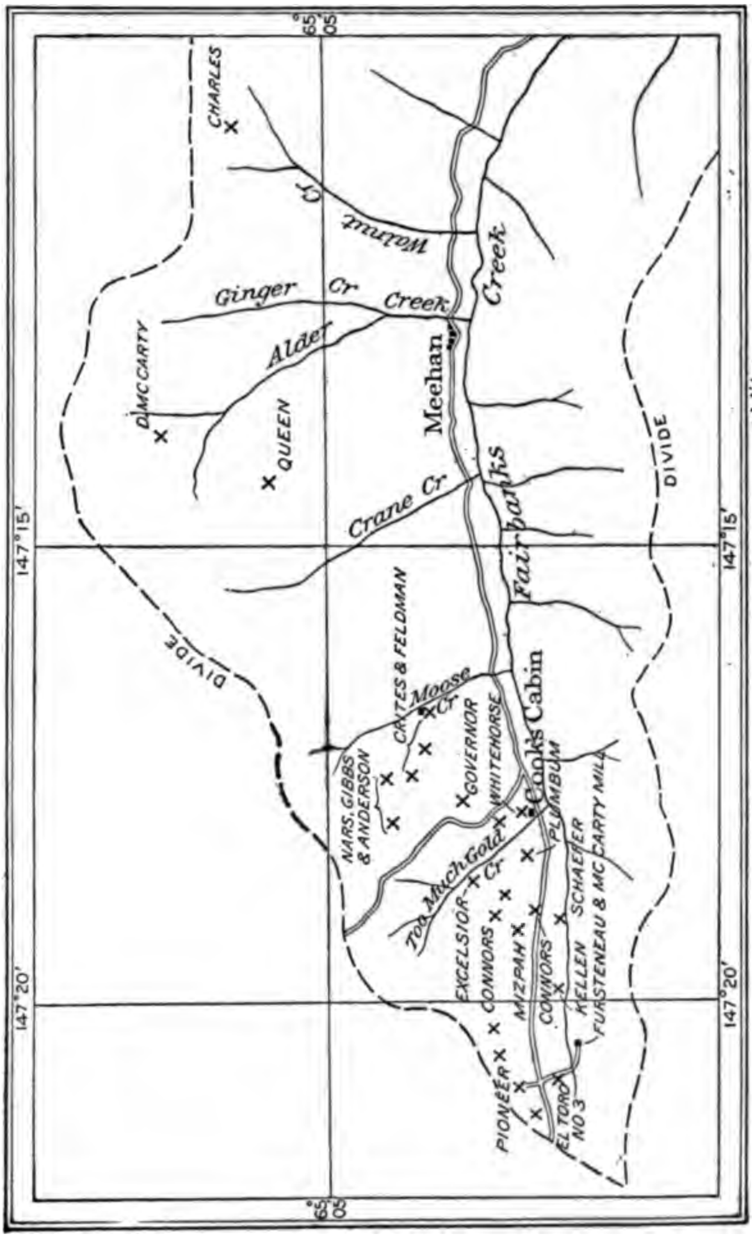


FIGURE 4.—Sketch map showing location of lode prospects in Fairbanks Creek valley.

vein was offset by a nearly vertical fault but was found by a short drift along the fault plane toward the north. About 250 feet from its mouth this tunnel is connected with the surface by an inclined raise of 65 feet along the vein.

The veins have been traced from a point near the creek to the ridge between Moose and Too Much Gold creeks, a distance of two claim lengths, by prospect pits and trenches. Several veins are evident, but not enough work has been done to determine their relations. They have a general northwesterly direction but are not parallel.

Although the entire length of the tunnel is in ore, considerable variation of the gold content is evident from place to place. Portions of the vein where sulphides are the most abundant form richer zones, and although not sharply differentiated from the leaner parts of the vein, these zones, which are roughly parallel, have impressed upon the vein a rude structure dipping into the hill. It was noticed by the miners in driving the tunnel that rich ore was first encountered in the roof.

Enrichment of the surface material by oxidation is pronounced in places. The upper tunnel for 150 feet from its mouth is in the oxidized zone. From this portion of the tunnel 23 tons of ore yielded an average of $130 a ton, and the vein is known to be equally rich in a number of places on the surface. Two assays show a fineness of 0.857 and 0.850 for gold and 0.133 and 0.140 for silver, indicating an average value of about $17.72 an ounce.

At the time of visit work was confined principally to surface trenching of the rich portions of the vein. At present the ore is hand picked and hauled to a near-by mill for treatment, but the owners plan to install a mill on the property in the near future.

Adjoining the property of Crites & Feldman is the Teddy R claim, on which a tunnel has been driven for 150 feet along a ledge of gold-bearing quartz. Considerable ore has been shipped from this claim, and at present the owner is at work developing the lode.

TOO MUCH GOLD CREEK.

Development work was continued on the property of Nars, Anderson & Gibbs on Too Much Gold Creek. Some difficulty was experienced with foul air, considered to be due to the arsenical iron in the ore, and work in the lower part of the shaft was abandoned. This trouble is now remedied by a raise to the surface from the west drift on the 60-foot level, which has provided an adequate circulation of air to ventilate the lower workings.

At the time of visit in 1913 work was temporarily discontinued, but operations were being planned for the coming winter. A small test mill with one 50-pound stamp, which is increased to about 150-pound efficiency by the use of additional weights and a spring, is used for sampling ore. It is planned to do more development work before installing a larger mill.

A number of other prospects have been opened on Too Much Gold Creek, and from some of them shipments of ore have been made. Little work, however, was done in 1913, and at the time of visit no work was in progress.

WEST OF TOO MUCH GOLD CREEK.

Development work has been continued on the Mizpah claim, which is situated on Fairbanks Creek half a mile east of the mouth of Too Much Gold Creek. This claim is being developed on a near-by vertical eastward-trending quartz vein. The vein has been opened to a depth of 120 feet by a shaft and drifts turned off at the 80-foot level.

The Ohio and Mayflower claims are being opened by Connors & Stevens. Some development work was done in 1913, but at the time of visit neither of the workings was accessible.

Northwest of the Mizpah claim, at an elevation of 1,980 feet, George Perrault has located the Minnie and Aroostook claims and made a surface opening on a ledge striking N. 80° W. and dipping 60° S. At the time of visit the workings were caved and could not be adequately examined. The ledge consists of three or four nearly parallel veins of quartz inclosing masses of schist, all more or less mineralized. Limonitic material taken from the dump is said to occur in veinlike formation parallel to the quartz vein and to contain small amounts of both gold and silver. Narrow reticulating veinlets of stibnite occur in both quartz and schist, and a yellow-green stain of antimony oxide is abundant.

Near the head of Fairbanks Creek are a number of other claims which were not visited in 1913, as none were in operation and little if any recent work has been done. Some have proved to be valueless and others are involved in litigation.

UPPER FISH CREEK VALLEY.

PEARL CREEK.

On the upper tributaries of Fish Creek several promising lodes are being exploited. (See fig. 5.) The greatest amount of work has been done by Perrault & Murphy on a group of claims near the divide between Pearl and Smallwood creeks. On the American claim an inclined shaft was driven 60 feet along a mass of quartz said to strike N. 50° E. and dip 60° NW. At the time of visit the lower workings were flooded and the shaft was timbered, so the relations could not be studied. The ore body is described as a very irregular mass of quartz ranging in thickness from 6 inches to 3½ feet. Ore on the dump is principally white glassy quartz with few sulphides. Examination of thin sections of the rock shows the quartz to contain fragments of quartzite and schist partly replaced by the vein and altered to chloritic matter. A second injection of quartz is shown by veinlets which cut the main lode. Specimens of black quartzite breccia cemented with white glassy quartz are said to come from the upper part of the vein, which for a depth of 9 feet is made up of this rock. This appears to be a bed of quartzite schist which did not admit of a clean-cut, open fracture in the process of vein formation but instead was brecciated. The tendency of a strong vein to split into stringers when it traverses quartzite beds has been noted in other places in this region.

The footwall of the quartz body is a zone of schist about 3 feet wide, mineralized with small stringers of quartz. Very little gold is visible in the hand specimens, but gold may be panned from nearly any sample of the vein taken at random. At the time of visit in 1913 plans were being made for the erection of a mill in the near future.

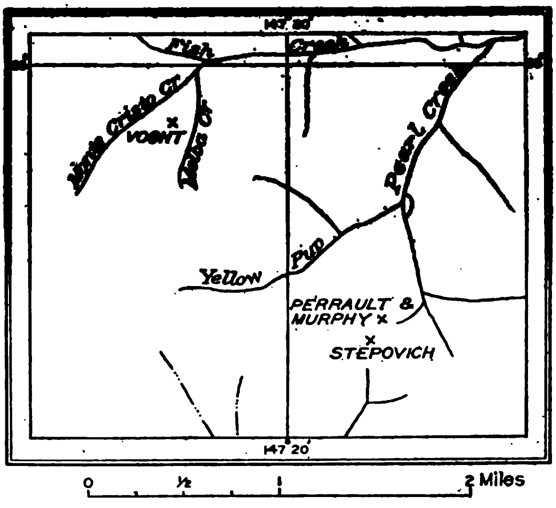


FIGURE 5.—Sketch map showing location of lode prospects in upper part of Fish Creek valley.

Michael Stepovich is prospecting a lode adjoining the Perrault & Murphy property on the southwest and has sunk a shaft 38 feet deep on a vein of quartz striking N. 70° E. and dipping 70° NW. At the time of visit no work was in progress and the shaft was inaccessible, but pieces of ore on the dump showed the vein to be mainly white milky quartz similar in appearance to that on the adjoining property. In the quartz vein are bunches composed essentially of arsenopyrite but containing a little pyrite. Fractures in the sulphide masses are cemented by veinlets of scorodite derived from the alteration of the iron and arsenic minerals.

MELBA CREEK.

On the ridge between Melba and Monte Cristo creeks, tributaries of Fish Creek near its head, a bismuth-bearing gold quartz vein is being prospected by Edward Voght. An opening made on the vein was inaccessible at the time of visit, but samples taken from the surface exposure show the vein to be mainly quartz carrying a small amount of intergrown native bismuth and bismuth sulphide. The vein, which is said to be about 5 inches thick, stands nearly vertical, trends east, and cuts fine-grained biotite granite. In the specimens collected particles of visible gold are plentiful, embedded in the bismuth minerals or in the quartz. Determinations made in the laboratory of the Geological Survey show the presence of tellurium. The mineral in which it occurs was not determined.

CLEARY CREEK VALLEY.

WOLF CREEK VALLEY.

PENNSYLVANIA MINE.

The Pennsylvania mine is situated on Wolf Creek near the Fairbanks divide, at an elevation of 2,100 feet. (See fig. 6.) The underground development consists of an inclined shaft 146 feet deep, 20-foot drifts east and west on the 50-foot level, and several raises, one of which connects with the surface. A Little Giant mill with a capacity of 8 tons of ore a day was built last October near the head of Fairbanks Creek, half a mile from the mine. Over 100 tons of ore has been milled from the Pennsylvania and other properties. Water for milling is obtained from Fairbanks Creek and for short runs the supply has proved plentiful. Neither the mill nor the mine was in operation at the time of the writer's visit in 1913, and the underground workings were not examined.

No fair tests have been made to determine the actual tenor of the ore, for mill tests made in Fairbanks, which yielded very high returns, were made on selected material, and the only ore treated in the mill near the mine was waste from which the high-grade material had been picked for shipment. More rock must be milled before the value can be determined. No production was made in 1913.

HOMESTAKE MINE.

The Homestake mine is situated near the head of Wolf Creek at an elevation of about 1,500 feet. The property was located by August Balzimer in 1908, has been intermittently worked by the Homestake Mining Co., and in the spring of 1913 was leased to George Nightingale.

Several veins, all having a general easterly trend, were traced on the surface and a development tunnel was driven southward to intersect them at depth. The greatest amount of work has been done on a vein striking east and dipping 45° S., intersected by the tunnel 320 feet from its mouth. At this point the vein is barren, but a short drift extending westward for 50 feet along the vein revealed a pocket

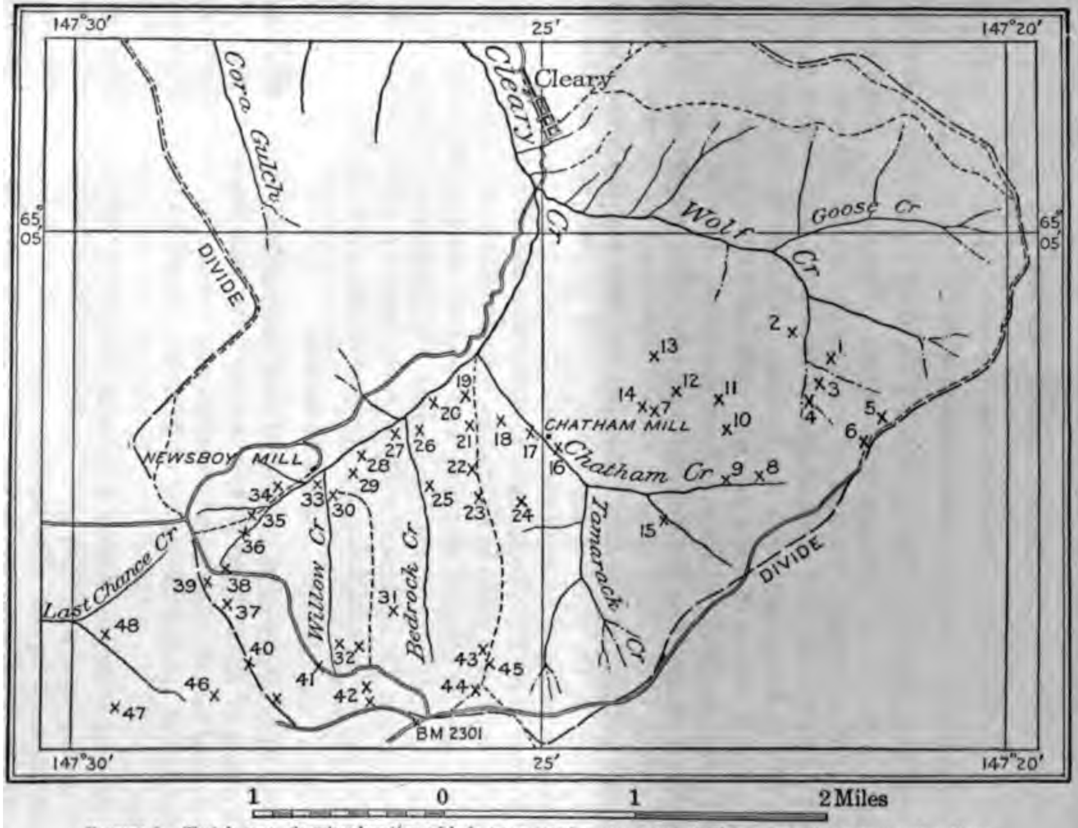


FIGURE 6.—Sketch map showing location of lode prospects in upper part of Cleary and Eldorado Creek valleys.

1. Banner.
2. Solomon.
3. Rexall.
4. Homestake.
5. Pennsylvania.
6. Dorothy.
7. Empire.
8-9. Chatham Mining Co.
10. Harris & Brown.
11. Quemboe Bros.
12. Fursteneau.
13. Quemboe Bros.
14. Jupiter-Mars.
15. Roughneck.
16. Pioneer.
17. Rex.
18. B.-P.
19. Cunningham.
20. Lyons.
21. California.
22. Pauper's Dream.
23. Alabama.
24. Bobbie.
25. Wyoming.
26. Rhoads Hall.
27. Stepovich.
28. Crosscut.
29. Tolovana Stibnite.
30. Tolovana.
31. Hess & Burnet.
32. Emma.
33. Stibnite.
34. Scheuyemere.
35. Eldorado.
36. Steil.
37. Sunrise.
38. Newsboy Extension.
39. Newsboy.
40. (?)
41. Cornell.
42. Cheyenne.
43. Your Jim.
44. Jackson.
45. Silver King.
46. Rose.
47. Thompson.
48. Hidden Treasure.

of very rich ore. The most work has been done east of the tunnel. A drift has been opened along the vein for 300 feet and a number of stopes worked out, roughly outlining two ore shoots separated by barren portions of the vein. At the west end of the drift the vein is low in gold content, but eastward from a point 90 feet from the main tunnel the floor of the drift is in ore for 160 feet. Beyond to the end of the drift, a distance of 50 feet, the vein is barren and split up into stringers. The downward extension of the ore shoot has not been determined except at one point where an incline along the vein for 8 feet showed the vein to pinch out. (See fig. 7.)

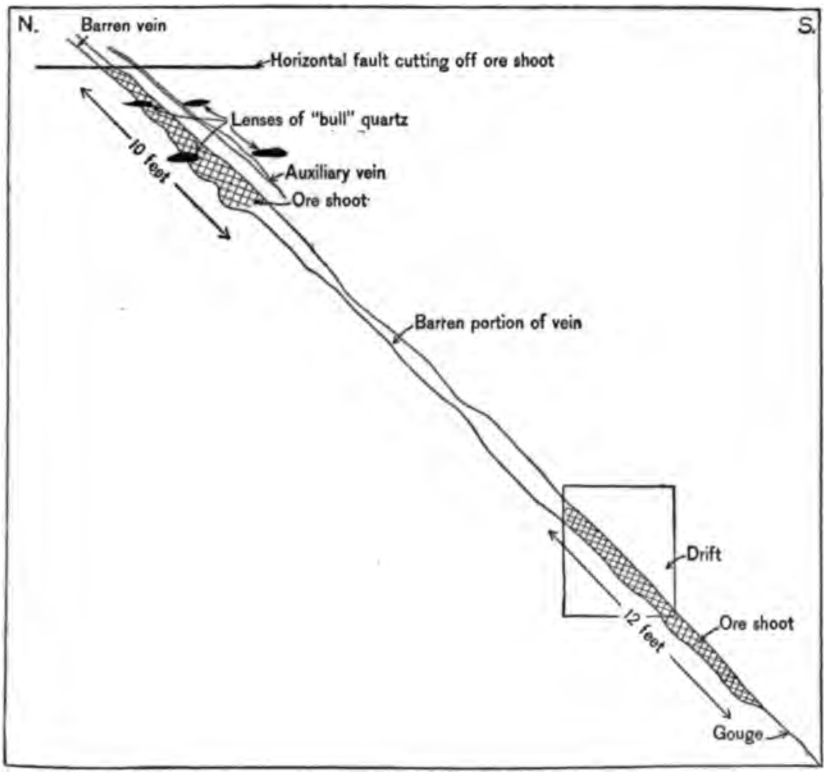


FIGURE 7.—Cross section of lode in east drift of Homestake mine, showing relation of ore shoots.

At a point 135 feet from the mouth of the drift a 150-foot raise to the surface shows the vein to be continuous, although much of it is barren of gold. This raise intersects another ore shoot 30 feet above the lower one, bounded on its upper limit by a horizontal fault with no apparent displacement of the vein, indicating a movement parallel in direction to the strike of the vein. Striæ indicate the same relative direction of movement. Much of the upper ore shoot has been stoped out, proving a length of at least 100 feet. This ore shoot, which is about 10 feet thick, has a nearly horizontal pitch. The vein is from 3 inches to a foot wide and averages about 9 inches.

The barren portions of the vein between the ore shoots differ but little in general appearance from the productive parts, which can be determined only by sampling. Lenses of "bull" quartz in the country rock appear to be more abundant adjacent to the ore shoots than along the leaner portions of the vein, and this association is said to be so general that when drifting along a vein the miners interpret an abundance of quartz lenses in the country rock as evidence of a rich portion of the vein. Some of the lenses of quartz that are cut by veins are mineralized and are hard to distinguish from the later vein quartz.

The main tunnel has been driven for 750 feet and has cut three other small veins. One near the mouth dips steeply to the north. About 600 feet from the mouth of the tunnel a quartz vein striking N. 60° W. and dipping 45° NE. was cut and drifted along for 100 feet. It averages a foot in width but locally widens and narrows. At the face of the drift it pinches to a gouge seam. Movement has occurred along the walls of the vein, and in one place the vein is faulted with small displacement. At the face of the tunnel is a stringer vein dipping south.

The vein matter is composed of iron-stained crystalline quartz with many open spaces. Sulphides are not abundant. Stibnite forms in isolated bunches in the vein, and pyrite and chalcocite, the black sulphide of copper, occur sparingly. Specimens taken from the dump show a parallel intergrowth of quartz and bladed crystals of chalcocite, giving the vein a granitic texture. Associated with the chalcocite are blue and green incrustations of copper carbonate, and throughout the vein are vugs and veinlets of limonite, oxidation products of the original vein minerals. The microscope shows a minute system of parallel fractures in the quartz resembling cleavage. Portions of the vein containing the copper minerals are said to be the richest in gold. Particles of visible gold occur in the quartz but are not numerous.

The localization of the gold in high-grade ore shoots, if such ore bodies are carefully delimited, makes milling costs less than if the same amount of gold were uniformly distributed throughout the vein.

REXALL MINE.

The Rexall mine, adjoining the property of the Homestake Mining Co., is being developed by Horton & Solomon. It was located in 1910 on a 5-foot quartz vein striking N. 25° E. and dipping about 25° NW. A tunnel was driven along the vein for 140 feet to an intersecting east-west vein, to the development of which subsequent work has been confined. A drift has been carried for 500 feet along this vein, giving a back of ore of 175 feet. Several upraises and winzes have been opened, blocking out stopes of ore, some of which have been worked out.

The vein material is essentially quartz with few sulphides. Along the hanging wall of the smaller vein, which is 12 to 18 inches thick, is an inch or more of gouge, and associated with it are narrow gash veins—lenses of quartz connected by veins of gouge.

A Joshua Hendy mill was installed in the fall of 1912. The mill has two stamps of 1,000 pounds each, with an 8-inch drop, and is equipped with a Blake crusher. The ore is trammed from the workings to the ore bins and automatically fed. An Otto gasoline engine furnishes power to run the mill and to pump 1,000 gallons of water an hour for the mill, at an expense of $14 each 24 hours for gasoline and cylinder oil. This is the only mill in the district that uses gasoline for fuel, and its comparative efficiency is being watched with interest by other operators. Water for the mill is pumped from a well beneath the engine room.

CHATHAM CREEK VALLEY.

CHATHAM MINE.

The Chatham mine, near the head of Chatham Creek, is on a vein averaging 6 to 18 inches wide, which, previous to underground work, was prospected by surface pits for a distance of 500 feet. The vein, which is located on the north slope of the valley, strikes N. 60° W., nearly parallel to the contour of the hill, and dips 65°–80° SW. A development tunnel 203 feet long cuts the vein about 95 feet below the surface, and from this point drifts 400 and 500 feet long have been driven northwest and southeast, respectively, along the vein. Raises were started every 35 feet and several have been extended to the surface, blocking out stopes of ore. Eastward for a distance of over 400 feet from a point 175 feet west of the face of the main tunnel nearly all the ledge from the main drifts to the surface has been taken out. The ore is extracted by stoping upward from the drifts and shooting the rock down.

The vein material is essentially quartz with low sulphide content. Wherever examined it was from 6 to 18 inches wide, but along the surface for a short distance in a portion now mined out the vein is said to have been only a seam of gouge. A narrow vein of stibnite striking east and dipping south cuts the main vein in the east drift about 150 feet from the main tunnel. East of this stibnite vein for about 200 feet, midway between the drift and the surface, a rich shoot of ore occurring in a horizontal lenticular mass was mined out. Its association with the stibnite vein suggests a relationship, although no enrichment of the quartz vein was noted along the intersection of the two veins at other places.

Movement parallel to the strike of the vein has produced horizontal striations along the walls but has not involved the vein to any great extent, although one displacement of 16 feet occurs along an east-west fault which cuts the vein on the west drift about 200 feet from the tunnel.

Although the value of the ore varies from place to place, no very rich bonanzas are known to occur in the vein, but considerable bodies of paying ore showing nearly uniform tenor have been blocked out, and the vein as far as worked has had few barren portions, so that practically all the rock mined can be milled. The downward extension of the ore body has not been determined.

The ore is trammed from the workings and temporarily placed in ore bins near the mine and taken to the mill by a downhill wagon haul of over a mile. From the ore bins at the mill it is automatically fed into the hoppers and crushed to pass a 40-mesh screen before flowing over the plates. The mill is a Joshua Hendy, equipped with two batteries of 1,000-pound stamps each. A 6-foot riffle box and double amalgam traps are used to catch any gold that passes the plates.

PIONEER MINE.

The Pioneer mine is located on Chatham Creek a quarter of a mile below the mouth of Tamarack Creek. The property was located as the Blue Bell lode in 1903, but little work was done until 1908, when it was developed. The property was not examined in 1913, for the mine was not in operation and the underground workings were inaccessible.

Since the completion of the mill in the fall of 1912 the Pioneer Mining Co. has milled 200 tons of its own ore besides considerable ore from other properties. The mill is a Joshua Hendy and has five 1,000-pound stamps, dropping 100 times a minute. The ore is trammed 300 feet to the mill, where the fines are automatically fed into the hopper and the coarser material is shoveled into the crusher. The pulp flows over two 10-foot amalgam plates placed tandem, giving a plate surface 20 feet long. An amalgam trap and auxiliary riffles fitted with cocoa matting are used but are said to be unnecessary. Assays on the tailings show them to contain from 50 cents to $3 a ton. No concentrator is used. Water for the mill is obtained in summer from Chatham Creek and in winter is pumped from an abandoned shaft which serves the purpose of a well.

OTHER PROPERTIES.

On the Gladstone claim, one of a group belonging to the Jupiter-Mars Consolidated Mining Co., situated half a mile northeast of the Pioneer mine, at an elevation of 1,700 feet, some ore has been produced, but no work was in progress in 1913 and the workings were inaccessible. Two tunnels were driven to open a flat-lying vein which dips south into the hill. East of the tunnel a shaft was sunk 125 feet to the vein and 112 feet of drifts turned off. The ore was treated at the Pioneer mill.

A small production of ore is reported from the Empire group of claims, adjoining the Jupiter-Mars property. Last winter a lease was taken on four claims of this group by Foster & Hungerford, who took out 14 tons of ore. No work was in progress at the time of visit in 1913, and the prospect was not examined.

On the Sunrise claim, at the junction of Cleary and Chatham creeks, a vein trending east and dipping 25° S. has been prospected by several open cuts and an adit that cuts the vein at a point 25 feet from the mouth of the opening, where a short drift was turned off to the west. The lode is about a foot thick and is composed of ribbons of rusty-looking quartz with wide seams of blue gouge and included lenses of schist. Fresh breaks show the quartz to be opaque and dull, and no sulphides are apparent in the vein material. Cavities in the quartz are filled with limonite. On the dump are specimens of quartz impregnated with stibnite and containing veinlets and coatings of antimony oxide, different from any rock seen in the vein. The face of the inclined adit was flooded with water so that the opening was inaccessible 30 feet from the mouth.

BEDROCK CREEK VALLEY.

RHODES-HALL MINE.

Active work has been continued on the Rhodes-Hall property, which continues to be the principal producer of the district. The vein is composed essentially of quartz with few sulphides and averages about 12 inches in width. The mine has been developed by three adits, which with underground connections, drifts, and crosscuts represent over 3,000 feet of work. The main tunnel has been driven along the vein for 1,280 feet, and about 500 feet of auxiliary openings has been made. From this adit an inclined shaft was sunk along the vein for 112 feet, and at the 70-foot level and at the bottom of the incline drifts were turned off aggregating nearly 1,000 feet in length. The Penrose tunnel has opened the vein for 280 feet. It is 140 feet above the main tunnel and is connected with it by a 160-foot winze. Much of the ore included between these two tunnels has been taken out.

Last October an electric pump was installed to remove the water which collects on the lower levels. It is operated continually and pumps over 50,000 gallons a day. The water thus obtained is used in the mill but is unsatisfactory, as the scale which it forms on the boilers and heaters is very troublesome.

TANANA QUARTZ & HYDRAULIC MINING CO.'S CLAIMS.

A group of claims belonging to the Tanana Quartz & Hydraulic Mining Co. and located on Bedrock Creek south of the Rhodes-Hall property is being worked by Antone Goessmann. The location of the claims was made on a north-south vein and two nearly parallel ones striking N. 75° W., which have been opened in a number of places.

In the summer of 1913 work on this property was confined to surface trenching of the richer portions of the veins. This serves the double purpose of prospecting the lead and producing high-grade ore for shipment. The method of working is to uncover the vein along the surface and to sample it constantly by crushing the rock and panning it to determine the gold content. The richer portions thus determined are taken out to a depth of about 10 feet and are hand picked and sacked ready for shipment. The rejected rock is stored for future treatment in case a mill is installed on the property or facilities are provided for treating lower-grade ore. A shipment of 4½ tons of ore was treated at the Pioneer mill and another lot of 4 tons was ready for shipment in August, 1913.

JACKSON CLAIMS.

The Jackson lodes are located on the ridge between Bedrock and Tamarack creeks, about a quarter of a mile northwest of bench mark 2301. On the Silver King claim a shallow opening has exposed a flat-lying lode about a foot thick, parallel to the foliation of the schist. The lode is bordered by ribbons of quartz with stringers of pyrite, arsenopyrite, and derived products. The center is composed essentially of sulphantimonite of lead. Tests made on this mineral showed it to carry considerable silver. Small masses of associated pyrite and arsenopyrite have been largely altered to scorodite.

On the Your Jim and Our Jim claims, a short distance below the open cut on the Silver King claim, a prospect tunnel has been driven 428 feet in quartzite schist. About 70 feet from the mouth the tunnel cut a quartz stringer which contains gold and silver. The tunnel also cut a series of nearly east-west parallel faults that dip steeply to the south. Narrow seams of gouge along the fault planes are said to contain considerable gold. A zone of crushed quartz and blue gouge bordering a fault 300 feet from the mouth of the tunnel contains heavy concentrates but no free gold.

On the east side of the ridge between Willow and Bedrock creeks, near the crest, at an elevation of 2,025 feet, some work has been done on a lode supposed to be the same vein that is being opened on the Emma claim. A shaft sunk by Hess & Burnett last winter was flooded and inaccessible, and no information regarding the deposit was procured. On the dump were pieces of quartz containing stibnite and considerable pyrite and limonitic material.

WILLOW CREEK VALLEY.

TOLOVANA MINE.

The Tolovana mine is on Willow Creek about 300 yards from the mouth. The main development work has been done on an eastward-trending vein which dips 60° S. A short distance above the mill the vein has been opened by a tunnel which has been driven eastward along the vein for a distance of 330 feet and by a number of short crosscuts. Two inclines sunk along the vein—one a shaft at the mouth of the tunnel and the other a winze 95 feet from the mouth—are connected at the 100-foot level by a drift, and the block of ore between these openings, 9,500 square feet in area, has been taken out and milled. Another drift was extended eastward from the eastern winze along the vein on the 50-foot level and a short winze was started at the eastern face of the drift. Considerable ore has been stoped out above the workings of the main tunnel and the 50-foot level.

The lode is composed of stringers of quartz inclosing lenses of schist. The quartz is dull and opaque and contains few open cavities. The gold is native but appears to be associated with the stibnite that occurs scattered through the vein in needle-like forms. The quartz stringers are frozen to the country rock, and the rock mined and milled as ore therefore contains besides the quartz the included mineralized horses of schist and considerable wall rock, all more or less impregnated with gold-bearing sulphides.

Northeast of the Tolovana mill, on the Tolovana-Stibnite claim, another stibnite-bearing vein has recently been prospected. A shaft was sunk on an eastward-trending vein for 100 feet, and at the 50-foot level drifts were turned off to the east and west for 50 and 30 feet, respectively. A raise 24 feet west of the shaft connects the 50-foot level and the surface, and the block of ore thus outlined has been stoped out and milled. No further work has been done on this property, although the amount of gold obtained in the mill run shows the lode to be workable ore. The vein is composed of quartz with considerable stibnite and lesser amounts of other sulphides. Yellow antimony oxide, in places stained red and brown by mixtures of other alteration products, is common.

The most promising vein on the property is one recently uncovered and at the time of visit just being opened. The vein strikes east and the surface dips 50° S. It is nearly parallel to the main vein in the mine. It is being opened by a shaft from which drifts will be driven east and west to prospect the vein, and if results warrant it a crosscut will be run from the mine. The lode is a strong vein of quartz from 18 inches to 3 feet wide with two well-defined walls separated from the vein by gouge seams. It thus differs notably from the stringer lode exposed in the mine.

The surface outcrops show considerable stibnite occurring as irregular veinlets and masses consisting of needle-like crystals. Particles of visible gold are common in both stibnite and quartz. Assays on the surface portion, considered by the operators to be a fair sample of the vein, showed a high gold content.

In September, 1912, a 2-stamp Nissen mill replaced the Huntington mill originally used and was run for two months. Since that time it has been used only for making test runs, but it is hoped that the opening of the recently discovered vein will furnish a constant supply of ore, so that the mill can be run continuously.

EMMA CLAIM.

The Emma claim is on the east side of Willow Creek, near the head, at an elevation of 2,100 feet. An east-west vein has been opened by an inclined shaft 60 feet deep, from which drifts 30 and 70 feet long have been turned off to the east and west, respectively. On the surface the vein dips 60° S., but in depth it flattens to 45°. The vein where exposed in the workings is composed of 4 to 12 inches of quartz with well-defined walls and thin gouge and separates readily from the inclosing rock. Fine particles of visible gold appear in specimens of the ore. The vein has been traced by surface pits for several hundred feet, and near the creek an opening was made, which is now caved in. Another tunnel is being driven to crosscut the vein and connect with the underground workings, thus prospecting the lode for a considerable distance and providing an adit for the removal of ore.

CLEARY CREEK ABOVE WILLOW CREEK.

NEWSBOY MINE.

A quarter of a mile south of the saddle between the heads of Cleary and Last Chance creeks the Newsboy mine is being developed on a vein that trends about northeast and dips 73° NW. The underground development consists of an inclined shaft parallel to the vein, drifts on the 60, 115, 150, 215, and 315 foot levels, and connecting winzes and stopes. A large stope extends northeastward from the shaft for 75 feet and is connected with the lower level by a winze, blocking out a quantity of ore.

The 115-foot level extends 140 feet southwest and 100 feet northeast of the shaft, and much of the ore between it and the 150-foot level has been taken out. A few feet east of the shaft the vein splits into two large branches and a number of smaller ones inclosing considerable schist. At this place the vein reaches a thickness of 14 feet. The entire ledge including the schist horses is mineralized, and all the rock taken out is milled.

The 150-foot level has been driven 200 feet northeast and 140 feet southwest of the shaft.

On the 215-foot level drifts extend 225 feet southwest and 175 feet northeast. Northeast of the shaft this level is connected with the upper level by several winzes, blocking out a number of sections of ore.

No work was being done on the 315-foot level at the time of visit. About 250 feet of drifts have been turned off, but they are flooded with water and inaccessible. This level is now used as a reservoir. All seepage water from the mine is allowed to collect there and is pumped out as needed during the winter. Water for summer use is obtained from a spring near by.

A 5-stamp Hendy mill was installed at the mine in the fall of 1911 and for the first year was run with water pumped from the mine, but this supply proved inadequate, so the mill was moved. It now stands 600 feet below the mine, on the north bank of Cleary Creek, on placer claim "No. 11 above." Water for the mill is pumped from a well near the present site. The ore is brought from the mine by wagons, a distance of nearly a mile. It is planned to drive a tunnel from a point near the present site of the mill along the vein on the 600-foot level and eventually to connect with the present workings. This would determine the continuity and gold content of the ledge and reduce operating expenses by lessening a long wagon haul and the power necessary to lift ore to the surface.

The vein is composed of dull granular quartz and contains a large amount of sulphides. It varies in width from a few inches to 14 feet and includes many horses of schist. The tenor of the ore mined varies considerably, depending in large part on the amount of included wall rocks.

OTHER PROPERTIES.

The Newsboy Extension mine has not been operated for some years and the underground workings are flooded.

A group of claims on the ridge between the heads of Willow and Cleary creeks, south of the road leading to the Newsboy mine, at an elevation of 2,400 feet, has been prospected by a number of openings. An old tunnel and shaft were both caved, and pits recently opened were filled with water, so that little could be learned of the relations. Pieces of quartz on the dumps showed little or no sulphide mineralization.

ELDORADO CREEK VALLEY.

On the headwaters of the various branches of Last Chance Creek, the main tributary of Eldorado Creek, a little prospecting has shown the presence of a number of gold-bearing lodes.

The Sunrise claim, east of the Newsboy mine, at an elevation of 1,975 feet, has been prospected by a number of surface pits. The openings could not be examined in 1913 on account of the dirt and water which had accumulated. On the dumps were fragments of quartz which apparently occurs in narrow stringers in the schist.

About a quarter of a mile south of the Newsboy shaft, at an elevation of 2,100 feet, is the Rose claim, which has been prospected by L. Goyett and others. At the time of visit the underground workings were flooded and only the surface exposures could be examined. A 4-foot vein of quartz striking N. 10° E. and dipping west has been opened by an inclined shaft which follows the vein for 50 feet. From the bottom of the incline a vertical shaft was sunk 25 feet deeper and a 20-foot crosscut run to the vein, which at this place is reported to be 8 feet thick. Ore from this part of the vein is composed of glassy quartz with considerable pyrite and arsenopyrite. No accurate figures were obtained to show the quantity of gold contained, but specimens of this ore crushed and panned by the writer yielded a good showing of colors. The gold is said to be concentrated in rusty fractures which penetrate the quartz.

On the same claim an 8-inch vertical vein striking N. 70° W. has been opened by a shallow pit near the shaft house and has been traced westward for some distance. The vein is glassy quartz with considerable arsenical pyrite.

The workings on the Thompson claim are half a mile west of the Rose shaft, at an elevation of 1,775 feet. A 24-inch vein of quartz was first opened for 15 feet by a vertical shaft, and 40 feet below the mouth of the shaft a tunnel was started to cut the lode at this depth but was driven nearly parallel to it for 100 feet. A crosscut turned off for 20 feet in the direction of the vein opened a 5-inch quartz stringer but failed to locate the large vein exposed on the surface. The country rock is black mica schist and black graphitic schist. Both the quartz stringer and the adjacent wall rock are said to contain gold.

The Hidden Treasure claim, located in 1909 by L. Goyett, is near the main forks of Last Chance Creek, at an elevation of 1,350 feet. The east end of the claim joins the Newsboy property. A tunnel was driven 250 feet on this claim to open a mineralized fault zone. Horizontal movement in an east-west plane is indicated by the direction of grooves produced along vertical polished walls. Gash veins have been deposited along fractures as nonpersistent lenses of quartz, forming a stringer lode which does not extend to the face of the workings but seems to pitch beneath the level of the tunnel. The vertical range of mineralization has not been determined. Gold may be panned from the quartz stringers and included schist, but the exact value of the rock is not known. A mill run was made on a shipment of ore taken near the mouth of the tunnel, but no returns were obtained, as the amalgam was lost.

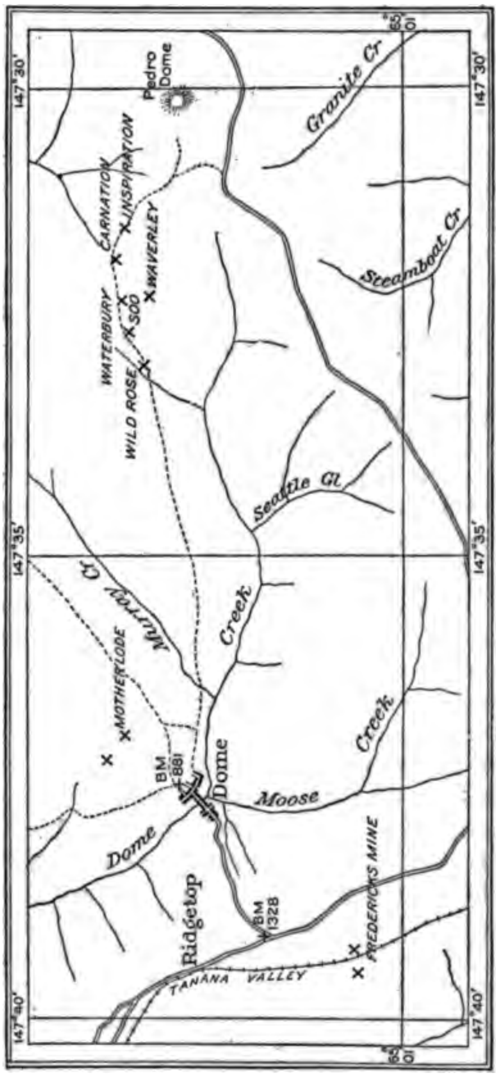


FIGURE 8.—Sketch map showing location of lode prospects in Dome Creek valley near top of ridge.

DOME CREEK VALLEY.

Near the head of Dome Creek (see fig. 8) is a group of claims which has attracted unusual attention, owing to the reports of high-grade ore produced. The property has been developed under lease by several companies and is now held by the Reliance Mining Co., but Capt. W. L. Spaulding, one of the locators, has, with various associates, been the principal operator, and the property locally bears his name. On the expiration of the Spaulding-Ronan-Cunningham lease the property was taken over by Spaulding & Brumbaugh, who, under the name of the Soo Mining Co., are developing the Soo and adjoining claims under lease from the Reliance Mining Co. A portion of the Wild Rose claim is leased to McGillvray & Ellis.

Location was made on two east-west veins which are nearly parallel but converge toward the east and also with depth. The northern vein is named the Soo vein and the other one the Wild Rose. Intersecting these two at about 45° is the chief vein, which dips 50° NW.

The Wild Rose vein has been developed by an inclined shaft which follows the vein for 100 feet on the end line between the Wild Rose and Soo claims. On the Soo claim, the principal producer of the group, drifts 440 and 300 feet long have been turned off to the east on the 50-foot and 100-foot levels, respectively, and the vein has been mined out and milled between the surface and the 50-foot level for 350 feet east of the shaft and between the 50 and 100 foot levels for 200 feet. Most of this work has been done since December, 1912. The vein has been traced westward by a short drift on the 100-foot level on the Wild Rose claim, and it is also being developed by an inclined shaft on the same claim. At the time of visit in 1913 this shaft was down 60 feet and drifts had been run from the bottom for 15 feet on the vein in both directions.

Faulting has displaced the vein in a number of places. Near the surface, in a stope now mined out and filled with waste, the vein was displaced for some distance along a fault fissure vein, and in the lower level a number of nearly parallel faults have broken the vein into irregular blocks connected by seams of gouge caused by drag along fault planes, and the same stresses have sheared the small fault blocks, causing movement along a system of minute parallel planes. This movement, in places at least, was later than the sulphide mineralization and has involved particles of both stibnite and gold.

Sulphides are not abundant, but small bunches of stibnite with a little galena occur in the vein, and tetrahedrite and sulphides of copper are reported.[1] The richest portions are localized in ore shoots which appear to dip eastward. These rich portions of the vein have a shattered appearance and evidently have been enriched by gold-bearing solutions introduced later than the formation of the vein. Within the ore shoots are small pockets of very rich ore, with many fine aggregates of visible gold. Locally the vein widens and narrows both horizontally and vertically, and here and there it pinches to a mere seam of gouge.

The Soo vein has been prospected by a 100-foot shaft on the line between the Soo and Waterbury claims and by other openings, none of which were accessible at the time of visit in 1913.

The Soo Mining Co. maintains two mills. Near the shaft of the mine a small mill of local manufacture is used for making test runs. It is equipped with three stamps of 250 pounds each and has a capacity of about 3 tons of ore a day, but its capacity is limited by

---

[1] Smith, P. S., op. cit., p. 179.

the available water supply, which is obtained by pumping from the shaft and is sufficient for only three or four hours a day. The mill, however, serves its purpose for making test runs, which are much more satisfactory than assays. A Joshua Hendy mill equipped with two 1,000-pound stamps is situated on Dome Creek half a mile from the mine and 600 feet lower in elevation. The ore is crushed at the mine and delivered by wagons to the ore bins at the mill, where it is shoveled into the hopper and crushed to pass a 40-mesh screen. The pulp flows over the plates into a Pierce amalgamator, which catches all quicksilver and rusty gold that pass the plates. Water for the mill is taken from the creek. Bunches of pure sulphides when noticed in the ore are not milled but are thrown aside to prevent sliming the plates.

The mill was installed in November, 1912, and since that time has been able to treat all the ore produced by the property. The capacity is about 10 tons of ore in 24 hours. The location was chosen as the most convenient for the water supply and also with a view to future operations. The plan of the operators is to start a crosscut tunnel near the mill, at the proper elevation to deliver rock to the ore bins, and drive it northward to cut the ore bodies at about the 600-foot level. This would prospect half a mile of ground, provide an adit for the removal of ore, and save hoisting and a subsequent downhill haul. It would seem advisable, however, to prove the vein to a greater depth before driving a long tunnel to the lower levels.

VAULT CREEK VALLEY.

The Fredericks mine, on the east slope of Vault Creek valley, was not in operation at the time of visit in 1913, although some development work has been done and a small production is reported.

A vein on the Bunker Hill claim, on Wildcat Creek, was prospected last spring and a test run made on a shipment of 8 tons of ore. The ledge is said to be 24 inches wide at the surface.

GOLDSTREAM CREEK VALLEY.

ROSE CREEK.

On Rose Creek, the main tributary of Gilmore Creek, considerable prospecting has revealed a number of quartz veins, but at the time of visit in 1913 only one man was working. Near the head of the eastern branch of the creek William Brown is developing several claims, situated near the contact of the porphyritic granite with schist. On the west side of the creek, about 2,000 feet above the mouth of Evening Star Creek, on the Green Mountain claim, a small open cut has been made on a large quartz vein at least 15 feet across. About

60 feet to the east a tunnel started to crosscut this vein has intersected a brecciated mass of schist with numerous local slips, containing small quartz veins and gouge seams between blocks. Not enough work has been done to determine the extent of the quartz. No assays have been made, but free gold can be panned from the crushed rock.

The Woodpecker claim lies in the granite area southeast of the claim just described. Here seven holes from 5 to 20 feet deep have disclosed the presence of a number of narrow seams of quartz and quartz-feldspar rock. The weathered surface of the granite is reported to contain small quantities of gold.

Near the dome on the ridge between the heads of the main forks of Rose Creek, at an elevation of 1,825 feet, a prospect hole has opened a lode 6 to 8 inches wide, striking N. 30° E. and dipping 70° NW., composed of quartz and feldspar. A 15-foot shaft and incline has been put down following the vein. A line of prospect pits at right angles to the strike of this vein has opened several other parallel veins. The only result of mineralization apparent is a small amount of stibnite in tiny veinlets. A number of other locations have been made on Rose Creek, some on lenses of bright glassy quartz showing no trace of metallization.

A dark-green schistose rock composed essentially of serpentine and magnetite is said to contain platinum, but no trace of this metal was found in samples submitted for analysis to E. E. Burlingame & Co., of Denver.

STEAMBOAT CREEK.

On Steamboat Creek several claims have been located and a little development work done. (See fig. 9.) These locations are on the fork entering from the north, about a quarter of a mile from its mouth. On the east side of the creek is the Silver Dollar claim, on which a tunnel has been driven into schist for a distance of 25 feet. The only result of mineralization apparent is a network of tiny veinlets of quartz along joint and fracture planes in the schist. A few cavities are filled with limonitic material, but no visible gold or sulphides are apparent.

Across the creek on the May Florence claim is an abandoned tunnel, now inaccessible, and on the hillside above it a shaft has been sunk 23 feet with the evident intent of connecting with the tunnel. The shaft is opened along a brecciated mass of schist with much blue gouge but no quartz lying between two parallel faults. A cabin stands on the property, but no one was working there at the time of visit.

GRANITE CREEK.

On the Birch & Anderson property, on Granite Creek about three-quarters of a mile above the mouth, the developments consist of a shallow shaft and a tunnel 390 feet long which intersects three parallel lodes. These have a general easterly direction.

The most southerly lode is a brecciated zone in the schist, healed with numerous quartz stringers strongly impregnated with pyrite and arsenopyrite.

The middle lode, known as the "blue-clay lead," is cut by the tunnel 186 feet from the portal. It is a 50-foot ledge composed principally of quartz inclosing horses of country rock and veined by numerous seams of blue-clay gouge. Both quartz and schist are strongly impregnated with pyrite and arsenopyrite.

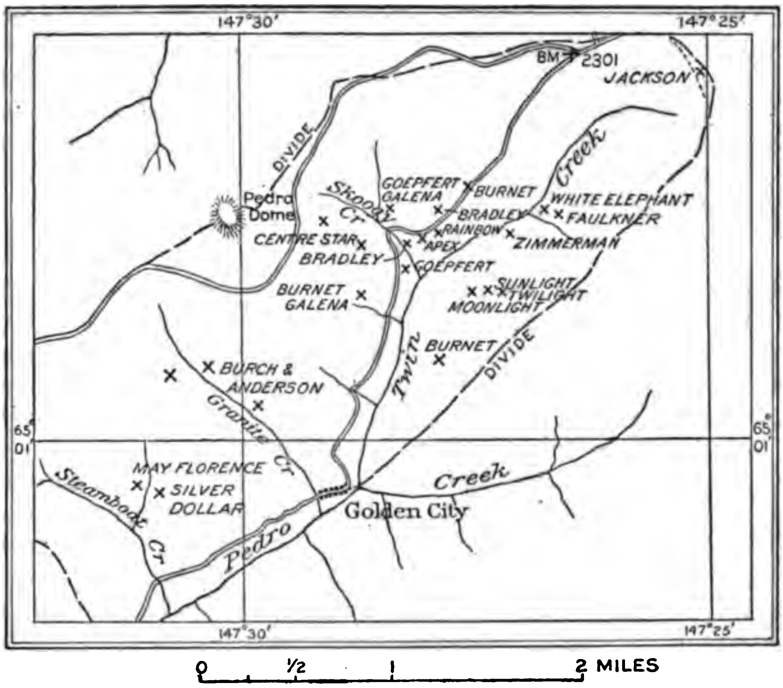


FIGURE 9.—Sketch map showing location of lode prospects in Twin, Skoogy, Steamboat, and Granite Creek valleys.

Extending for 30 feet to the face of the tunnel is the third lode, composed of quartz carrying arsenopyrite and pyrite and specks of free gold. The discovery was made on this ledge, and a shaft was sunk on it for 14 feet. The tunnel that was run to intersect it at depth disclosed the other two ledges.

At the time of visit assays were being made to determine the value of the prospects, but the result was not learned. The third lode is the only one that is interesting the owners at present, as the ores of the other two are known to be base, and in this locality little interest is now being taken in other than free-milling ores. The size of this ledge and the ease with which a large amount of ore could be extracted favor further exploitation of this property.

TWIN CREEK VALLEY.

UPPER TWIN CREEK.

A number of locations have been made at the head of Twin Creek, and a little development work has been done by Nerich, Jackson & Faulkner. On the White Elephant claim a 20-foot tunnel was driven but has caved in, obscuring the relations. Flat lenses of galena lying parallel with the foliation of the schist are associated with stringers of quartz. One such body of galena measuring 9 by 5 feet and 5 inches thick was taken out and milled. It is reported to have carried considerable silver. A little pyrite occurs with the galena. Alteration of the galena has resulted in cerusite and an impure mixture of lead oxide and limonite.

RAINBOW MINE.

The Rainbow mine, situated east of Skoogy Gulch, is developed on an 18-inch nearly vertical east-west quartz vein which occupies a fault plane traversing schist, quartzite, and granite. Besides a short drift on the 50-foot level two main drifts 135 feet and 190 feet long have been driven to the east and to the west respectively from the 100-foot level and two chambers stoped out.

Underground workings and surface prospecting have roughly outlined the upper surface of a pitching ore shoot. Prospect pits and surface trenching show the ore to extend from the west end of the claim to a point 12 feet east of the shaft; beyond this point the vein is of low tenor. On the 100-foot level the ore extends to a point 135 feet east of the shaft. Between these two points the boundary between ore and vein material of very low grade extends in an irregular but definite line that is 35 and 100 feet distant from the shaft on the 50 and 65 foot levels respectively. To the west ore has been proved for 240 feet on the surface and 190 feet on the 100-foot level, and it is assumed that the included portion of the vein is also ore. This ore body thus appears to be an eastward-pitching ore shoot with a stope length of at least 325 feet.

At the time of visit no work had been done on this property since May, 1913. Previous to that time 480 tons of ore had been shipped. A 10-stamp Straub mill with an electric amalgamator was erected last spring and an experimental run made on 45 tons of ore, but as this was not considered successful the mine was closed. It is the hope of the operators to install a 5-stamp Hendy mill and resume work in the near future.

HARRAIS CLAIMS.

Across the creek from the Rainbow mine a promising lode has been located on the Moonlight, Sunlight, and Twilight claims. This property was taken over last spring by Martin Harrais and is being actively developed. The vein has been traced by prospect pits for 2,500 feet and in this distance shows no displacement through faulting, although it is broken into small irregular blocks between which some movement has taken place. The vein strikes N. 70° W. and dips steeply northeast. It cuts both quartzite schist and granite, but the proved productive part lies wholly within the schist.

An ore shoot with a stope width of at least 650 feet extends across parts of two claims. In this ore body the discovery shaft has been sunk to a depth of 50 feet, and 20 feet of drifts have been turned off. No accurate sampling has been done, but rock taken at random from different parts of the ore body is said to contain gold in paying quantities. Over 100 feet of tunnel has been driven to cut this ore body at depth.

The average width of the vein is less than a foot, but locally it swells and pinches, ranging from a few inches to over 4 feet. The vein is composed of quartz with a considerable amount of sulphides occurring in veinlets that are evidently of later origin than the deposition of the quartz. Gold occurs both in the quartz and in the sulphides. Subsequent to metallization the vein has been brecciated, providing narrow crevices in which particles of gold have collected.

BURNET LODES.

On the east side of Twin Creek, below the mouth of Skoogy Gulch, a Mr. Burnet has opened up some gold-bearing quartz. In working a narrow bench placer deposit it was discovered that the irregular granite bedrock and the adjoining bank contained gold, so as much of the weathered surface of the granite as could be removed easily was shoveled into the sluice boxes with the gravel. This work disclosed the presence of a number of parallel quartz veins. The gold in the granite is thought to be due to concentration from the brecciated surface portion of the veins.

The Burnet quartz lode, on the west side of Twin Creek, has been opened by a short open cut that exposes only the weathered part of the vein. The lode is a flat-lying body of quartz in the center of which are lenses of galena. The quartz has many cubic cavities containing limonitic material, probably derived from pyrite. Next to the lenses of galena the quartz is banded with alternating layers of limonite. The galena-bearing lode is later than at least part of the fissuring which followed the intrusion of the granite, as it cuts a vertical vein of quartz which cuts the granite. An assay of the galena is said to show a rich silver content. Secondary minerals which have formed fr the alteration of the galena are pyromorphite and cerusite. These occur as incrustations and are evidently of no value as ore minerals.

SKOOGY GULCH.

On Skoogy Gulch considerable prospecting has been done, but none of the properties have yet reached a producing stage.

ESTER CREEK VALLEY.

HUDSON MINE.

Little work is being done in the vicinity of Ester Creek except on the Hudson mine (see fig. 10), located on the ridge between Ready Bullion Creek and Moose Gulch, at an elevation of about 1,500 feet. A vertical shaft had, at the time of visit in 1913, been sunk 180 feet and a number of levels turned off. The principal work has been done on the 100-foot level, a plan of which is shown in figure 11. From the station 20 feet west of the shaft the "big lead" has been opened

FIGURE 10.—Sketch map showing location of lode prospects in Ester Creek valley and vicinity.

for 160 feet north, to a point where it is abruptly cut off by a fault perpendicular to the direction of the tunnel and dipping 60° SW. A polished and striated fault plane covered with gouge marks the hanging wall of the ledge, which appears to be a crushed zone, 15 feet wide, filled with stringers and lenses of quartz and masses of mineralized schist enveloped in gouge. The footwall is less clearly defined but is marked by a seam of gouge along which vein matter and wall rock easily separate. Along the fault that cuts off the ledge at the north end of the drift a crushed zone 2 feet thick, similar to the ledge, has been healed with quartz stringers.

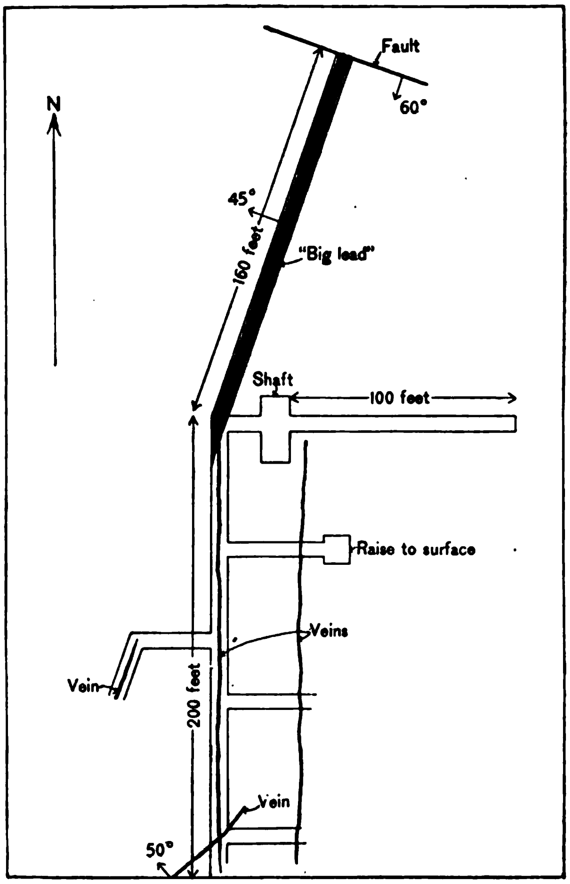


FIGURE 11.—Plan of 100-foot level of Hudson mine, showing various lodes.

Another lode opened on this level is called the "spur vein" by the miners, as it appears to join the larger vein. It may be an older vein cut by faulting previous to the formation of the larger vein. It has been opened by a drift from the station west of the shaft for a distance of 200 feet to the south. It averages 4 inches in width and is composed of dull, opaque quartz with many open cavities into which well-formed quartz crystals project. Many of these crystals and some fractures are covered with a black coating of manganese oxide. Stibnite, the only sulphide detected, occurs sparingly. Where the vein traverses soft schist it is nearly solid quartz, but in quartzite it splits up into very narrow veinlets which are hardly distinguishable from the country rock. The amount of gold in the vein at such places is said to be small. At one locality a quartz lens included in the schist has been cut by this vein and has been mineralized with gold and stibnite by the tiny branches of the anastomosing quartz vein.

About 100 feet from the station a crosscut from this drift toward the west for 30 feet opened a ledge that is probably the continuation of the "big lead," whose strike would bring it near this point. Near the end of the drift a stringer was cut which strikes N. 45° E. and dips 50° NW. It is composed of brecciated iron-stained quartz.

Crosscuts driven east of this drift and one driven east of the shaft have tapped in a number of places veins of quartz, which from their position and similarity are thought to be parts of the same ledge. This ledge is composed of a number of stringers of quartz and included schist. All is more or less mineralized, as well as the inclosing wall rock for several inches from the vein. Individual stringers show a variety of dip, but the lode maintains a general north-south trend.

The best ore is said to occur in stringers in the "big lead" from the surface to the 70-foot level and is found in very rich shoots. At the time of visit no ore was being milled, as work was confined to proving the extent and values of the known veins and the possible occurrence of other ore bodies before attempting to mine out ore already blocked out.

READY BULLION CREEK BASIN.

The Farmer lode, situated on the divide between Nugget and Ready Bullion creeks west of Ester Dome, has been opened by Hudson Bros. on a lease. An inclined shaft was sunk 60 feet on a north-south vein, which dips about 45° E., but work was abandoned as the results did not encourage further development.

On the Flagler prospects, north of Ester Dome, only assessment work has been done.

The Cotton Blossom and Barker & McQueen claims have been prospected by William Harp. On the Cotton Blossom claim a tunnel and crosscuts aggregating 100 feet were driven in a mineralized area. A number of small stringers were cut, but no definite lode was found. On the Barker & McQueen claim two shafts, 40 and 45 feet deep, were sunk and an incline was driven along a narrow stringer for 100 feet. A short drift turned off from the incline cut a ledge said to be 4 feet wide, from which 4 tons of ore was milled and yielded fair returns. Work will be continued on this prospect.

The Blue Bonanza claim, at the head of the western fork of Sheep Creek, has been prospected by a shaft 130 feet deep. A surface zone from 12 to 15 feet deep yielded small pockets of very rich ore, but the rock below this zone is said to be low in gold content.

About a quarter of a mile from the mouth of the creek Tyndall & Finn have located several claims and done a little development work.

EVA CREEK BASIN AND VICINITY.

Considerable prospecting has been done on the ridge between Eva Creek and the headwaters of Ace and St. Patrick creeks. (See fig. 12.) Some promising lodes have been uncovered, but little work was in progress at the time of visit in 1913.

George Comstock has opened several claims on the east slope of Eva Creek about three-quarters of a mile from Ester Creek. On the Crown Point claim an inclined shaft has been driven for 20 feet along two narrow quartz veins, one 2 inches and the other half an inch thick, filling parallel joints in schist. These veins, which strike N. 40° W. and dip 65° SW., are separated by 4 feet of soft chloritic schist with joint planes parallel to the veins. Along the hanging wall of the larger vein is a narrow seam of gouge. The adjacent schist for about 7 inches is altered to yellow sticky clay. The quartz veins contain specks of visible gold and the wall rock is said to contain a little gold.

In the saddle northwest of the Ryan lode at an elevation of 1,300 feet the Fairchance claim is being developed by McGlone & Smith. From the bottom of a vertical 40-foot shaft 120 feet of levels have been opened, besides a short drift on the 18-foot level and a stope near the surface. The surface exposures showed no definite lead but a mass of crushed schist and quartzite, with considerable quartz, also badly crushed and mixed with blue gouge, all containing small amounts of free gold. The underground workings show the continuation of this mineralized zone dipping steeply in a general southeasterly direction. Stringers of quartz and seams of blue gouge penetrate schist and quartzite, which are somewhat crushed but less so than the surface rock.

On the 40-foot level the southeast crosscut has opened this mineralized zone from a point 15 feet from the shaft for a distance of 45 feet to the face of the opening, where it is cut off by a fault striking N. 30° E. and dipping about 70° SE. In a parallel crosscut on the 18-foot level this stringer lead has been opened for 30 feet. Near the surface on the northwest side of the shaft a stope has been opened, disclosing an irregular-shaped body of quartz, much of it crushed to a fine powder and so crumbly that it can be shoveled like gravel. This appears to be the surface portion of a northwestward-dipping

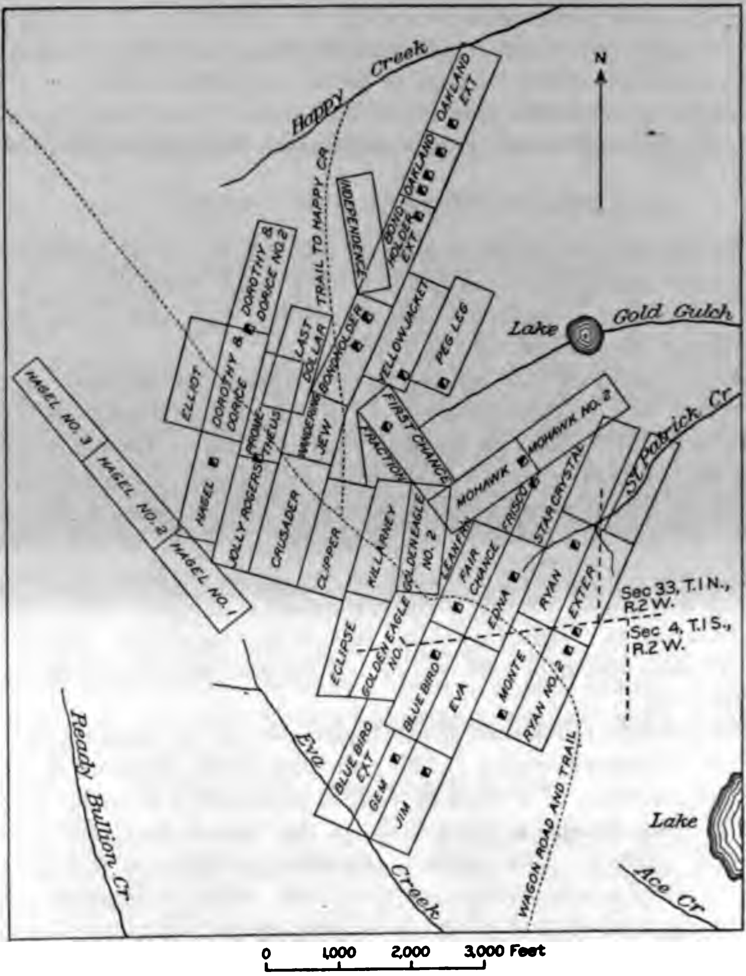


FIGURE 12.—Sketch map showing claim locations at head of Eva Creek.

vein, which should be found in place at depth by crosscuts driven northwest.

Several other claims are being worked by McGlone & Smith. Near the head of Happy Creek the Dorothy and Dorice and Dorothy and Dorice Extension claims have been located on what appears to be the same lode, striking N. 40° E. The openings are now caved. On the Frisco claim a vein striking N. 45° E. has been prospected by a 20-foot shaft from which 70 feet of drifts are turned off. On the surface the vein dips 30° NW., but it appears to steepen in depth. The ledge, which is about 11 feet thick, is composed of several parallel veins of quartz with much included schist. Along a well-defined hanging wall movement has taken place in the direction of the dip of the vein, as shown by striations on the gouge. Small quantities of gold are contained in both the quartz and the included schist.

A short distance below the Dorothy and Dorice claim a shaft has been sunk on the junction end line between the Prometheus and Jolly Rogers claims by Hess & Thomas. The workings were not accessible, but samples taken from the dump show the ore to be white opaque quartz, badly crushed and containing angular fragments of clearer quartz. The microscope shows a fine aggregate of crystalline quartz containing fragments of an older quartzose rock. A still later phase in vein formation has been the sulphide metallization in the form of fine veinlets of stibnite. A coating of antimony oxide has given the rocks in places a greenish-yellow stain.

Near the head of Gold Gulch, the north fork of St. Patrick Creek, Tyndall, Finn & McLoughlin have located a number of claims and have done some development work. On the Bondholder claim a lode which strikes N. 20° E. and dips 40° NW. has been traced for 500 feet on the surface and opened by an incline for 20 feet along the vein. The ledge is about 6 feet wide and is composed essentially of quartz with inclusions of fragments and lenses of schist. A seam of gouge marks the hanging wall, along which the richest ore occurs in a quartz stringer having a greenish color. Particles of free gold occur in the quartz but were not detected except along the hanging wall. Sulphides were not noted in the vein. The footwall is not well defined but is made up of a number of parallel joint planes, each with a narrow seam of gouge. The vein has been traced across three adjoining claims, the Bondholder Extension, Oakland, and Oakland Extension.

PLACER MINING IN THE YUKON-TANANA REGION.

By Theodore Chapin.

During an examination of the Fairbanks lode region in 1913 a few notes were gathered relative to the progress of placer mining in the Fairbanks district and other parts of the Yukon Valley. Many of the data were obtained from operators and others, and special thanks are due to Messrs. N. G. Myers, of Eagle; Frank Morrison, of Circle; George L. Morrison, of Hot Springs; and R. C. Wood, of Fairbanks.

FAIRBANKS DISTRICT.

GENERAL CONDITIONS.

The value of the placer gold produced in the Fairbanks district in 1913 was $3,300,000. The production in 1912 was valued at $4,150,000. This falling off was due to a general drought, which affected the entire Yukon Valley. No rain fell until the later part of July, and all placer-mining operations were hampered by lack of water. This drought and the early freeze up in the fall combined to make the working season unusually short.

About 130 plants were working a whole or part of the summer season, employing probably 1,500 to 1,800 men. Much less work was done in the winter. The customary wages of $5 a day and board (reckoned at $2 a day) were paid. Although 200 men left Fairbanks for the new diggings at Chisana Creek, no shortage was felt. New discoveries were made on Alder, Smallwood, and Happy creeks. The productive areas of Chatanika Flats, at the mouths of Dome and Cleary creeks, continue to increase, and on Fairbanks and Dome creeks new productive ground was discovered.

The tendency is toward the open-cut method of mining, and some claims are now being profitably mined in this manner which have heretofore been considered too deep. Two innovations in mining appliances are the wheel scraper that was used on Pedro Creek and the underground scraper that was being tested in some of the deep workings on Chatanika Flats.

A power company has been organized to develop power in the Nenana coal fields by coal in winter and water in summer, to work the placers of Tatlanika and Totatlanika creeks, which are practically above water.

CHATANIKA RIVER BASIN.

Cleary Creek was the principal producer of the district, owing to the extension of the productive ground at the mouth of the creek in Chatanika Flats. Fifteen outfits employing about 250 men were at work on the creek during the summer. On Freeman Bench, opposite Discovery, prospecting has located a new pay streak.

A little mining is being done on the tributaries of Cleary Creek. Five outfits on Wolf Creek and three on Chatham Creek were attempting to work with what water was available.

The effect of the drought was felt less on Dome Creek than on other creeks in the district. Thirteen outfits worked for most of the season, enploying about 100 men during the summer. On the Chatanika Flats, near Olness, a number of large plants were successfully operated during the summer.

On Vault Creek considerable ground had been blocked out in preparation for the summer's work, but water was not available for the entire season. One hundred men were at work during a part of the season. The Alabama Association was the principal producer. Several other large groups were in operation.

On Treasure and Wild Cat creeks two outfits were working about 20 men.

On Little Eldorado Creek six plants were in operation in 1913, employing 75 men. The previous winter 20 men were employed blocking out ground. No work was done on Homestake Creek in 1913.

In the Chatanika Flats more mining is being done than ever before. Ten outfits employed 500 men during the summer. Two companies were experimenting with an underground scraper which digs and dumps automatically into a car 20 feet from the working face of the tunnel.

GOLDSTREAM CREEK BASIN.

Goldstream Creek continues to be one of the principal producers, although the production is falling off from year to year. The tendency is toward open-cut methods, and each year drift mines that have been failures are being successfully operated by open cutting. During the summer from 25 to 30 outfits employed 250 to 300 men. Winter work was carried on in the drift mines and a few men were employed on some of the open-cut mines in blocking out ground.

Seven men were working on First Chance Creek, a tributary that enters Goldstream Creek from the southeast near "No. 5 below." In August two men were working in Hansen Association claim. A shaft had been sunk 42 feet to bedrock and 56 feet of drifts turned off. The pay streak is said to be 4 feet wide and to contain $2 a square foot. Three other claims were being prospected. There was no production in 1913, but winter dumps were taken out.

On Pedro Creek 10 outfits were working during the summer of 1913, employing about 125 men. Little winter work was done, as the gravels are shallow and most of the mines employ open-cut methods. On claim "No. 8 below" a wheel scraper was being used for the first time. It has a capacity of 16 cubic feet and is said by the operator to be more efficient than the Bagley bottomless scraper, so universally used in this district, because it requires only one-third the amount of fuel to move the same amount of gravel. It is operated by two men and dumps automatically.

On Gilmore Creek six outfits were at work during the summer, employing 20 to 25 men. On New Years Pup, a branch of Rose Creek, one man was sluicing. Water was hardly sufficient for use, but by damming the creek enough could be collected to sluice for several hours at a time. The gold at this place is coarse.

No mining was in progress on Twin Creek in 1913, but it is reported that the Fairbanks Gold Mining Co. has secured an option on several claims with the view of installing a dredge.

On Engineer Creek three plants employed an average of 50 men during the summer of 1913.

FISH CREEK BASIN.

The production from Fairbanks Creek for 1913 probably exceeded that of the previous year. The productive area was increased by new discoveries in 1912 and also in 1913. The gravel deposits are deep, and both winter and summer work is carried on. The dredge of the Fairbanks Gold Mining Co. has been digging on Fairbanks Creek for three seasons. Early in the summer of 1913 the operators experienced considerable difficulty with low water, but later reports indicate that they had a fairly successful season. New discoveries have been made on Deep and Alder creeks, tributaries of Fairbanks Creek.

On Pearl Creek two outfits were at work at the head of the creek, and near the mouth of Yellow Pup four men were working part of the summer.

On Last Chance Creek and tributaries several small plants were in operation.

CRIPPLE CREEK BASIN.

The Cripple Creek basin continues to be one of the principal producers of the Fairbanks districts. Winter work was continued on a large scale. Summer sluicing operations were somewhat curtailed by lack of water. One plant on Ester Creek was not able to begin sluicing until September 1. The productive ground on Eva Creek continues to increase. Gold-bearing gravel was discovered on this creek in 1911. In the summer of 1913 five plants were in operation employing 125 men. On Ready Bullion Creek two plants worked during the summer, one employing 50 and the other 8 men.

New productive ground was found on Happy Creek, a tributary of St. Patrick Creek. The plant on the Gold Hill claim, on Cripple Creek, was in operation winter and summer and employed 30 men.

CIRCLE PRECINCT.

GENERAL CONDITIONS.

The value of the gold produced in the Circle district in 1913 is estimated to be $175,000. The production for 1912 was valued at $325,000. The decrease may be in part accounted for by the drought which affected the entire Yukon Valley. On many of the creeks no water was available for sluicing until late in the season, and many claims were not worked at all. Forty outfits, including two hydraulic plants, operated for the whole or a part of the season, employing about 150 men. Probably 100 men took out winter dumps, some of which were not sluiced for lack of water.

BIRCH CREEK BASIN.

The Elmer dredge started to dig on Mastodon Creek about the middle of June. Early in the summer its operation was hindered by lack of water, but later reports indicate a successful season. Difficulties encountered in 1912 with frozen ground were avoided this season by working entirely in thawed ground. The contract has been let for another dredge that will be installed on Mastodon Creek.

The Berry & Lamb hydraulic plant on Mastodon Creek was started early in the summer but was closed part of the season, as there was not sufficient water. A new hydraulic plant was installed by A. P. Clark.

On Deadwood Creek and tributaries from 40 to 50 miners were working winter and summer. Three men were mining on Portage Creek. Early in the season 1,300 feet of ground was stripped ready for sluicing. It was hoped to have sufficient water to work the entire season without any interruption. A new strike was reported from Preacher Creek.

It is reported that a hydraulic plant will be moved from Mastodon Creek and installed on Independence Creek. One outfit of 12 men was mining on Half Dollar Creek during winter and summer.

UPPER YUKON BASIN.

In August 10 men were mining on Fourth of July Creek and others were ready to work whenever the water supply was adequate. Later in the season more plants were in operation. New productive ground was found on Ruby Creek but was not extensively prospected.

Early in the season Woodchopper Creek gave promise of being a better producer than ever before. About 20 men were mining on the creek and its tributaries. Mining is carried on both in winter and summer. One outfit took out a winter dump on Boulder Creek and was preparing to sluice. Six or eight men were mining on Coal Creek.

SEVENTYMILE, EAGLE, AND FORTYMILE RIVER DISTRICT.

GENERAL CONDITIONS.

The value of the gold produced in the Seventymile, Eagle, and Fortymile River districts in 1913 is estimated to be $150,000. In 1912 the production was valued at $220,000. The drought was felt in this region as keenly as at any other place in Alaska.

One dredge was digging on South Fork of Fortymile River, near the mouth of Franklin Creek, and others are planned. It is the belief that large areas of low-grade ground in this region which can not be successfully worked in a small way can be profitably hydraulicked or dredged.

SEVENTYMILE AND EAGLE DISTRICTS.

By the middle of August about 35 men were at work in the Seventymile district, and later in the season, when water was more plentiful, the number was increased. In the Eagle district one hydraulic plant and several small outfits worked the entire season, employing about 20 men.

FORTYMILE DISTRICT.

In the Fortymile region about 25 miners took out winter dumps. The summer work was delayed by the lateness of the rainy season. In August about 50 men were at work and many others were ready to sluice whenever water was available.

The Atwater dredge on South Fork of Fortymile River, near the mouth of Franklin Creek, is reported to have had a successful season. Options were taken on a number of claims on Walker Fork and Davis and Poker creeks with a view of installing a dredge. Eighteen men were working on Squaw Creek with a bottomless scraper. Wade Creek is being gradually worked out. Considerable winter work was carried on, so the drought was less felt there than at some other places. No water was available in the early part of the season on Chicken or Denison creeks. Several outfits were mining on Ingle Creek. Negotiations are being made by a syndicate to control a large number of bench claims on Fortymile River and develop enough water to work them successfully.

SALCHAKET-TENDERFOOT REGION.

In the Salchaket region little work was in progress in 1913. On Tenderfoot Creek, Democrat Pup, and Banner Creek five plants were in operation, employing altogether about 50 men.

CHENA RIVER BASIN.

A small amount of mining was done on South and Middle forks of Chena River. On Smallwood Creek one outfit of five men was mining during the summer. A number of claims on Chena Slough, extending from a point half a mile below Fairbanks to Hyde's ranch, have been examined, and it is reported that a dredge is to be installed on them in 1914.

HOT SPRINGS DISTRICT.

The production of the Hot Springs district for 1913 is estimated to be worth $400,000. About 300 to 400 men were employed during the greater part of the season. The drought was less felt there than at many other places.

On American Creek several plants employed 30 to 75 men. Drifting methods are used and the gravel is raised to the surface by windlass. Several large plants were operating on Sullivan Creek, the principal producer of the district. Prospecting has extended the productive area on Sullivan Creek Flats near the mouth of Woodchopper Creek, where more auriferous gravel has recently been found.

In the Baker Creek basin, Thanksgiving, Omega, Glen, Gold Run, Eureka, and Seattle Jr. creeks were worked in a small way, mostly by ground sluicing or by open-cut methods. Considerable prospecting was done on Cooney and Killarney creeks.

RAMPART DISTRICT.

In the Rampart district 20 outfits were in operation in 1913, employing about 60 men. About 20 men took out winter dumps. Two hydraulic plants operated on Hunter Creek and a successful season is reported. On Dawson Creek and Idaho Bar winter and summer mining was carried on. Four or five men mined on Quail Creek during the winter and 10 in the summer. Winter and summer mining was done on Little Minook and Little Minook Jr. creeks. A successful season is reported, considering the water shortage. A new pay streak was discovered on the bench between the two creeks. Ten men were making open cuts on Slate Creek.

PLACER MINING IN THE RUBY DISTRICT.

By Henry M. Eakin.

FIELD WORK.

The Ruby district was revisited by the writer late in the summer of 1913, after a season of exploration in the Yukon-Koyukuk region. Several days were spent in examining the active plants and gathering data regarding the progress of mining since 1912. The success of this brief visit was greatly enhanced by the operators and residents of the district in their painstaking efforts to furnish exact data and to extend courtesies and hospitality. Special acknowledgment is due Mr. Charles Forander, one of the original discoverers on Long Creek, from whose records the data regarding production are largely taken.

PREVIOUS INVESTIGATION.

The Ruby gold placer district was visited by A. G. Maddren in 1910 and by the writer in 1912. A summary of the geographic and geologic data gathered in these years has been published,[1] and a more complete report is in press.[2] The present paper is intended only to supplement the sections on economic geology contained in these reports, so that the published history of the camp will include the mining season of 1913.

GENERAL OPERATING CONDITIONS.

The population of the district has fluctuated considerably since the fall of 1912 and has changed greatly in personnel. The general trend is, however, toward a larger and more permanent population. Labor has generally exceeded the demand at the current wages of $5 a day and board. In some instances lower wages have been paid.

Freight rates have been lowered somewhat from those of 1912 owing to increased competition among steamboat companies. General merchandise rates from Seattle to Ruby have been given as low as $30 and $35 a ton. Special classes of freight take rates 20 to 200 per cent above these figures.

---

[1] Eakin, H. M., Gold placers of the Ruby district and the Innoko-Iditarod region: U. S. Geol. Survey Bull. 542, pp. 279-303, 1913.

[2] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578.

Rough lumber has been reduced from $50 to $30 a thousand and dressed lumber from $80 to $60. Cordwood varies greatly in price, according to its availability. Many operators find it economical to hire wood cut and hauled by the day instead of at a fixed cord rate, the cost being lowered in some cases to $3 a cord. Extensive use and forest fires have greatly reduced the supply of fuel timber, so that in future this element in the cost of mining will generally increase.

Transportation from Ruby to the creeks in the summer of 1912 took a rate of about $10 a ton a mile. In 1913 this rate was reduced to $5 or $6 and even lower to some creeks. There was a corresponding reduction also in winter freight rates. This decline is due in part to increased competition in the business, in part to cheaper forage, and in part to improved roads.

An excellent Government road, used both in winter and summer, has been built from Ruby for 3 miles toward the creeks. From its end a winter road has been laid out over easy grades to the head of Long Creek. In summer the same trail is used as formerly, and it is for the most part extremely bad.

The water supply was exceedingly scant in 1913 owing to a prolonged drought. This seriously handicapped mining throughout the district, except the operation of plants equipped for pumping, and curtailed the season's total production from what could have been reasonably expected under ordinary conditions.

MINING.

GENERAL ACTIVITIES.

Mining was continued in 1913 on all the six creeks that produced in 1912, namely, Long, Upper Long, Midnight, and Trail creeks, Bear Pup, and Glen Gulch. The industry was also extended to eight other creeks of the district not previously productive—Lucky, Greenstone, Monument, Ophir, Poorman, Duncan, Tenderfoot, and Tamarack creeks.

CREEKS PREVIOUSLY PRODUCTIVE.

Long Creek.—Long Creek continued in 1913, as in 1912, to hold first rank among the creeks of the district in the extent of known placer deposits, the importance of mining operations, and the amount of gold produced. The placer deposits of Long Creek below the mouth of Bear Pup apparently form a fairly continuous pay streak of variable size and richness. It reaches southward from the Cheyenne fraction, at the Long Creek settlement, for a distance of about 5 miles to the Long Creek Association ground, where the mine farthest downstream was located in 1913. The course of the pay streak is entirely independent of the present stream and of the topography of the valley bottom. Consequently the depths of the mines vary, the bench mines being deeper than those on the present stream bottom. Considered in connection with surface elevations the depths of the mines show that the bedrock surface has a greater slope down the valley than the present flood plain. The Cheyenne fraction and Windy Bench mines, for instance, which are on a terrace 30 feet above the creek level at the north end of the pay streak, have depths of 40 to 50 feet. About 5 miles down the valley, on the Long Creek Association ground, is a productive mine whose shaft, starting at the flood-plain level of the creek, penetrates 85 feet to bedrock. Still greater depths are to be expected farther down the valley. In some of the deeper holes the gravels are thawed and ground water has given trouble. The deposits that may exist farther down the valley can be exploited only at much greater cost and risk than those upstream. The use of a drill in testing such ground is to be highly recommended.

The productive placer ground of Long Creek below the mouth of Bear Pup is held in nine association groups of claims and four fractional claims. Only one association group and two fractions were idle in the summer of 1913. Thirteen plants, employing about 125 men in all, were operated. The plants varied in capacity, but all were equipped with steam machinery that aggregated about 300 horsepower.

The winter work on Long Creek was confined chiefly to prospecting and blocking out ground. Five plants worked in a small way during the winter of 1912–13.

Upper Long Creek.—Claims Nos. 1, 2, 3, and 4 above Discovery, on Long Creek above the mouth of Bear Pup, were worked during the summer of 1913. During the previous winter the three claims above No. 1 were worked in a small way. The hand windlasses used in 1912 were replaced by steam machinery, the four plants aggregating over 100 horsepower. The later development work has shown the gold-bearing gravels to lie in irregular bodies rather than in pay streaks. This has required an unusual amount of prospecting, the results of which generally have not been all that could be desired. In places, however, very satisfactory ground has been opened. About 25 men were employed on upper Long Creek most of the summer and 6 men during the winter.

Bear Pup.—Claims Nos. 1 and 3 on Bear Pup were worked in the summer of 1913. The gravels are but 12 to 16 feet deep, and the mines are of the open-cut type. A single plant operated on each claim. Both were equipped with heavy steam machinery that was employed in scraping away the overburden, hoisting pay dirt to the sluice boxes, and pumping water for sluicing. The two plants aggregated 100 horsepower and employed 70 men continuously most of the summer. Rapid progress was made on both claims and the results were very satisfactory.

No winter work is done on Bear Pup except prospecting and testing values in known placer ground.

Midnight Creek.—As in 1912, but a single claim was worked on Midnight Creek. A small steam plant, including a hoist, installed on the Jennie Association ground the preceding winter, was operated in the early part of the summer by six men. Later in the season the force was reduced to two men, who continued work the rest of the summer.

Although gold is widely distributed along Midnight Creek, the development work done so far has failed to reveal concentrations rich enough to yield much profit in mining. Very little prospecting has been done away from the original discovery, however, and it may be that the same effort spent in prospecting, especially in the lower part of the valley, would yield better returns in the long run than can result from the mining of such deposits as have already been found.

Glen Gulch.—Mining on Glen Gulch was confined to the operation of three small plants, which were at a standstill most of the summer owing to the water famine. Two of the plants did little besides prospecting and the third took out a small dump during the summer to be sluiced during the fall rainy season. Not more than six men worked on the creek at any time. No winter work was done.

Trail Creek.—Trail Creek was unique in the district in the relatively great extent of its winter mining. Four plants employing 16 men operated on separate claims most of the winter. Of these, two were very successful, in view of the scale of operations, and made considerable production. Early in the spring the mine farthest downstream, 2½ miles below Discovery, shut down, and another mine was opened near the head of the creek, where some unusually good ground had been discovered during the winter. Four plants, employing about 30 men, were active throughout the summer. Owing to the scant water supply part of the winter dumps remained until late in the summer before they were sluiced.

The profitable mines of Trail Creek are all within 2 miles of the head of the stream. The pay streak is narrow and fairly continuous. It yields coarse gold for the most part. A nugget worth $296, the largest yet produced in the district, was taken from the new mine near the head of the stream early in the summer.

NEW PRODUCTIVE CREEKS.

Location.—Discoveries were made on eight new creeks in the Ruby district during the winter of 1912–13 and the following spring. Four of these streams are in the same general area with the creeks already producing. They are Lucky Creek, a westerly tributary of Flint Creek next north of Glen Gulch, and Greenstone, Monument, and Ophir creeks, which flow southward, the first to Long Creek, the others to Solatna River, in the area east of Long Creek below Midnight Creek. The other four new creeks drain an area that centers about 30 miles south of the Long Creek diggings. Three of these, Poorman Creek and its northerly tributaries, Duncan and Tenderfoot creeks, belong to the Innoko drainage system; the other, Tamarack Creek, heads against Duncan Creek and flows north to the Solatna.

Lucky Creek.—Lucky Creek is a small stream less than 3 miles in length and having no important tributaries. Its deposits are adapted for shallow drift mining, ranging from 16 to 30 feet in depth.

Two small plants, employing two and four men respectively, prospected separate claims on the creek during the winter of 1912–13. The work was continued during the following summer, but only a small production is reported to have been made.

Greenstone Creek.—Greenstone Creek is about 5 miles long. It heads in the same divide with Midnight Creek, near the same place, and flows southwestward to join Long Creek a little above its mouth. Shallow low-grade placer ground was located about 2 miles from the head of the stream in the winter of 1912–13. The known placers are all included in the Anaconda group—an association comprising four claims. The ground is 3 to 12 feet deep and is easily worked by open-cut methods. A single outfit employing five men worked throughout the summer. Lack of water for sluicing hindered the work greatly, but a profitable production was made. The cost of working this ground could be greatly lessened by the use of machinery, and in that case the outlook for the creek would be very encouraging.

Monument Creek.—Monument Creek is the next stream east of Greenstone Creek. It is about 8 miles long and flows southward to Solatna River. Good placer ground was discovered about midway in the stream's course, at and below the mouth of a small westerly tributary called Jack Rabbit Creek, during the winter of 1912–13.

Two plants, employing 17 and 5 men, respectively, were operated the whole summer of 1913. The ground is 35 to 40 feet in depth. It is well frozen, is adapted for economical drift mining, and is said to yield very satisfactory returns.

Some prospecting was done during the summer about 2 miles below the productive mines, and it is reported that pay dirt was struck at this locality late in August.

Ophir Creek.—Ophir Creek is the next stream east of Monument Creek and, like it, flows southward to Solatna River. Two outfits prospected on this creek in the early summer, one of which continued work throughout the season. A rich discovery was reported and preparations for active mine development were under way the last of August.

Poorman Creek and tributaries.—Poorman Creek is the extreme northeastern headwater of the North Fork of Innoko River. It is a stream of considerable size, being 20 to 30 feet wide and having considerable depth and velocity at ordinary stages. It is reported to have gone completely dry during the drought of 1913.

The geology of the Poorman Creek region is similar to that of the district to the north. The formations include schists, slates, and greenstones, probably of earlier Paleozoic age. Immediately south of these rocks are cherts and less altered igneous rocks that may be considerably younger. The country is worn down to a very low relief. The interstream areas are occupied by broad, smooth ridges deeply mantled with products of rock decay and possibly in some places with recent lacustrine sediments. The lower slopes of the ridges merge with wide valley bottoms that are analogous to the alluvial plains of the lower Innoko. Both the ridges and the bottom lands are timbered. The trees, mostly spruce and tamarack, are for the most part of rather stunted appearance. Good-sized trees are fairly plentiful, however, along the banks of the streams and at their heads.

The first prospects discovered in this region were taken from the stream gravels of Poorman Creek in the spring of 1912 by Thomas Armstrong at a point about 8 miles southeast of Twin Butte Mountain. Several holes were sunk to bedrock the following winter, and on March 7, 1913, gold-bearing gravel was hoisted from a hole near the original discovery by Armstrong and his partner, Gus Olson. Since then a great deal of prospecting has been done in the region, and valuable placers have been located at three separate localities on Poorman Creek and on two of its tributaries, Duncan and Tenderfoot creeks. The lowermost locality on Poorman Creek is about 1½ miles above the mouth of Tenderfoot Creek, and that farthest upstream, 5 miles above, is near the mouth of Duncan Creek. The locality on Duncan Creek is a mile above its mouth; on Tenderfoot Creek, half a mile above its mouth. The deposits are much alike wherever explored. Their depth ranges from 53 to 65 feet. The gold lies in a stratum of gravel on bedrock, 3 to 6 feet thick. The overburden is chiefly muck. The gold occurs for the most part in fine shot-like particles and shows the effects of transportation in wear and assortment. The widest crosscut in pay gravel on Poorman Creek is 125 feet, in the mine near the mouth of Duncan Creek. The development work done so far is not sufficiently extensive to demonstrate the existence of continuous pay streaks on Poorman Creek and its tributaries, but the evidence in hand all points in that direction. If this should prove to be the case, and if the width and richness of the deposits known to occur locally should prove to be general, the production from this part of the district should quickly assume large proportions.

Mining was done at times during the summer on Poorman, Duncan, and Tenderfoot creeks, five claims in all, each worked by a separate plant. But little machinery had been taken into the region, so that operations were necessarily conducted on a small scale. The miners were further handicapped by an absolute lack of water for sluicing during a greater part of the summer. About 15 men in all were employed in mining.

Tamarack Creek.—Tamarack Creek is about 8 miles long. It heads against Duncan Creek and flows northward to Salatna River. Prospects were found on the creek during the spring of 1912, and pay gravel was located the following winter at a locality about 3 miles from its head. A small outfit employing four men worked on this ground during the summer of 1913.

SUMMARY.

The mining industry in the Ruby district has shown on the whole considerable advancement over the preceding year. The six streams that produced in 1912 were worked again in 1913, most of them with a largely increased scale of operations. The changes were brought about mainly by the installation of heavy steam machinery in place of the light hoists and hand windlasses used before.

Placers were discovered on eight new creeks, some of which are very promising. Prospecting is being done on still other creeks, and in places results are being obtained that suggest the likelihood of a further increase in the number of producing creeks.

All told, there were 41 plants engaged in actual mining in the Ruby district in the summer of 1913, operating 38 claims on 14 different creeks and employing a total of about 230 men. Of the 41 plants 33 were equipped with steam machinery that aggregated over 750 horsepower. The other 8 plants used hand labor.

During the winter of 1912-13 twelve plants were operated on as many claims situated on three creeks. About 40 men were engaged on this work.

The winter production of the district amounted to $102,200. Data regarding the value of the summer's production are incomplete as yet, but it is estimated at $750,000.

MINERAL RESOURCES OF THE YUKON-KOYUKUK REGION.

By HENRY M. EAKIN.

INTRODUCTION.

The region in central Alaska lying between Yukon and Koyukuk rivers westward from the Yukon Flats has in general been little frequented by prospectors. Owing to the consequent lack of economic interest those parts of the region not immediately accessible from the rivers have long remained geologically unexplored.

The northwestern part of the region, along Koyukuk River, was visited by Schrader[1] in 1899, and the northeastern part, along Dall and Kanuti rivers, by Mendenhall[2] in 1901 and, along Dall River, by Maddren in 1909.[3] The areas along the Yukon have been touched upon by Dall,[4] Russell,[5] Spurr,[6] Collier,[7] Maddren,[8] the writer,[9] and others incident to general investigations along the Yukon or to the surveys of adjacent regions.

During the summer of 1913 a survey party in charge of the writer made a rapid reconnaissance through the more inaccessible and geologically unknown parts of the region. The journey embraced two stages, the first from Yukon River near Fort Hamlin northwestward to Hughes, on Koyukuk River; the second from Hughes southwestward to the Yukon near Ruby. It is the purpose of this paper to set forth a brief summary of the geography, geology, and mineral resources of the region as indicated by the investigations of the writer and of his predecessors in the same general field. A more comprehensive report is in preparation.

---

[1] Schrader, F. C., Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 441–486, 1900.

[2] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska: U. S. Geol. Survey Prof. Paper 10, 1902.

[3] Maddren, A. G., The Koyukuk-Chandlar region, Alaska: U. S. Geol. Survey Bull. 532, 1913.

[4] Dall, W. H., Exploration in Russian America: Am. Jour. Sci., 2d ser., vol. 45, 1868, pp. 97–98; Correlation papers—Neocene: U. S. Geol. Survey Bull. 84, p. 247, 1892.

[5] Russell, I. C., Notes on the surface geology of Alaska: Bull. Geol. Soc. America, vol. 1, 1889.

[6] Spurr, J. E., Geology of the Yukon gold district, Alaska, with a chapter on the history and present condition of the district by H. B. Goodrich: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 87–392, 1898.

[7] Collier, A. J., The coal resources of the Yukon, Alaska: U. S. Geol. Survey Bull. 218, 1903.

[8] Maddren, A. G., Placers of the Gold Hill district: U. S. Geol. Survey Bull. 379, 1909, pp. 234–237; The Innoko gold-placer district, Alaska, with accounts of the central Kuskokwim Valley and the Ruby Creek and Gold Hill placers: U. S. Geol. Survey Bull. 410, 1910, pp. 80–83.

[9] Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U. S. Geol. Survey Bull. 535, pp. 17, 34, 1913.

GEOGRAPHY.

The Yukon-Koyukuk region embraces an area of about 12,000 square miles in central Alaska, lying between Yukon and Koyukuk rivers westward from the Yukon Flats. Roughly speaking it extends from longitude 149° to 157° W. and from latitude 65° N. to the Arctic Circle, although considerable areas within these boundaries are not included between the rivers.

The relief of most of the region is low, but locally elevations rise to 5,000 or 6,000 feet. The main river valleys as a rule have extensive lowland plains. These plains are set in among areas of rolling, maturely dissected upland of moderate elevation that cover most of the region. The higher elevations are restricted to one relatively large mountainous area and several smaller ones. The larger area, occupied in part by the Ray Mountains, includes about 2,000 square miles in the northeastern part of the region and contains the headwaters of Ray and Tozitna rivers and of a southern tributary of Kanuti River. The highest known point in the area is about 6,000 feet above sea level. Numerous peaks rise above an altitude of 5,000 feet and considerable areas stand almost as high. Much of the area has an extremely rugged topography, which is largely a result of glaciation in late geologic time.

The smaller mountainous areas lie between Melozitna River and the Yukon, about the northerly headwaters of Indian River, and from the Melozitna Canyon northwestward for about 25 miles. The elevations within these areas nowhere greatly exceed 4,000 feet, but their features have a bold mountainous aspect owing to the general low relief of the adjacent country. There is evidence of alpine glaciation in places along the Melozitna-Yukon divide and a few miles northwest of the Melozitna Canyon. The glaciers here were much less extensive than those in the Ray Mountains, the longest not exceeding 2 miles in length.

The region is drained entirely by the tributaries of Yukon and Koyukuk rivers. The arrangement and relative size of the streams are shown on the map (Pl. XVI).

The climate of the region is semiarid and is characterized by the great seasonal variations in temperature common throughout central Alaska. The open season, available for sluicing and navigation, usually extends from early in May to the end of September. The growing season available for agriculture usually lasts about 3 or 3½ months. The ground below a slight depth is permanently frozen, in places to known depths of 130 feet or more.

The timber line in the region is about 2,000 feet above sea level. Locally, in protected valleys, trees grow at slightly higher elevations. In the mountainous areas timber grows only in the valleys and on the lower slopes. In the Ray Mountains the valleys are devoid of timber for a distance of 5 or 10 miles from their heads. There are large areas in the Melozitna basin below timber line that apparently have never been forested.

The principal species growing in the region are the spruce and birch. A few scattered tamarack grow in places and willows and alders thrive along watercourses and about timber line.

Except in favored situations along the banks of streams and at the heads of valleys the trees are small, generally measuring less than 1 foot in diameter. In favored spots trees 2 feet or more in diameter can be found, but the areas that support such growth are very small.

Forest fires have swept over large tracts in recent years, and in places repeated burnings have cleared the land completely. Probably half the area between Yukon and Koyukuk rivers was burned over in 1913. However, there is sufficient timber remaining in almost any part of the region below timber line for the ordinary uses of prospectors.

Game is generally abundant in all parts of the region not recently burned. Moose, caribou, and bear were encountered in considerable numbers by the Survey party. Small game and fish were to be had almost anywhere.

Steamboats ply on Yukon and Koyukuk rivers during the open season and furnish a ready means of reaching the border of the region. The larger tributaries of these rivers are generally navigable for poling boats for considerable distances, but much of the region is inaccessible in this manner. Melozitna River has a canyon near its mouth said to be impassable for craft of any sort. Above the canyon this stream is ideal for poling boats and furnishes a possible route through a large territory. Very little boating is done except on Tozitna and Kanuti rivers. Inland travel is mostly done in winter, when dogs and sleds can be used.

The population of the region is chiefly localized in settlements on the banks of Yukon and Koyukuk rivers. The white settlements include Rampart (population about 50), Tanana (300), and Ruby (1,000), on Yukon River, and Hughes (population 75), on Koyukuk River. Minor settlements along the rivers, including telegraph stations, road houses, and the like, have a total population of about 50 individuals. About a score of prospectors spend more or less time in the interior of the region.

The native population numbers about 300. They live in camps and villages on the banks of Yukon and Koyukuk rivers, usually near the mouths of important tributary streams. The two largest settlements are probably those near Rampart and Tanana.

The industries pursued by the inhabitants of the region are numerous, but all are related more or less directly to mining, transportation, and the Government military and signal service. An agricultural experiment station is maintained at Rampart under Government auspices, and a great variety of products have been grown there successfully.

Government mail service extends to all river settlements throughout the year, and the principal Yukon River settlements are in touch with the United States military telegraph lines.

GEOLOGY.

GENERAL FEATURES.

The sketch map (Pl. XVI) presents graphically a summary of the salient geologic features of the Yukon-Koyukuk region. It will be noted that a broad zone lying along the Yukon upstream from Ruby is occupied predominantly by metamorphic rocks, probably of Paleozoic age. Westward from Melozitna River to the Koyukuk the rocks are composed almost entirely of Mesozoic sediments. Between the metamorphic rocks on the east and the Mesozoic sedimentary rocks on the west is an area in which the rocks are predominantly igneous, being for the most part granitic intrusions and their metamorphic equivalents. Tertiary sedimentary rocks occupy small areas on the Yukon, on Ray River, and possibly in other parts of the region. Quaternary deposits are widespread and cover large areas of the older rocks. The most extensive of these is the alluvium of the lowland plains. At higher elevations are gravel and silt terrace deposits. Locally in the mountainous areas are considerable bodies of material deposited by valley glaciers. Much of the material now included in the terrace and alluvial deposits may be glacial outwash.

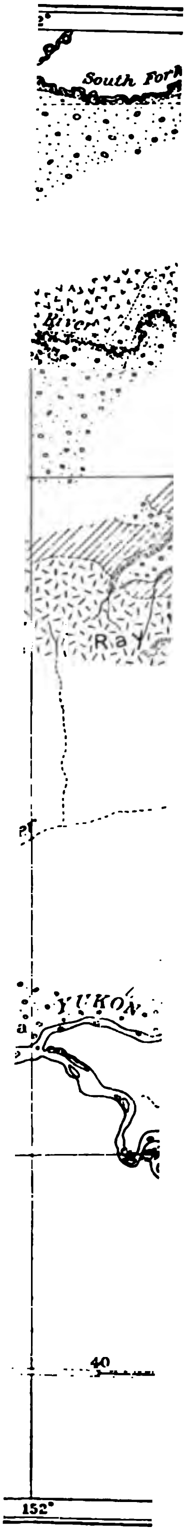
METAMORPHIC ROCKS.

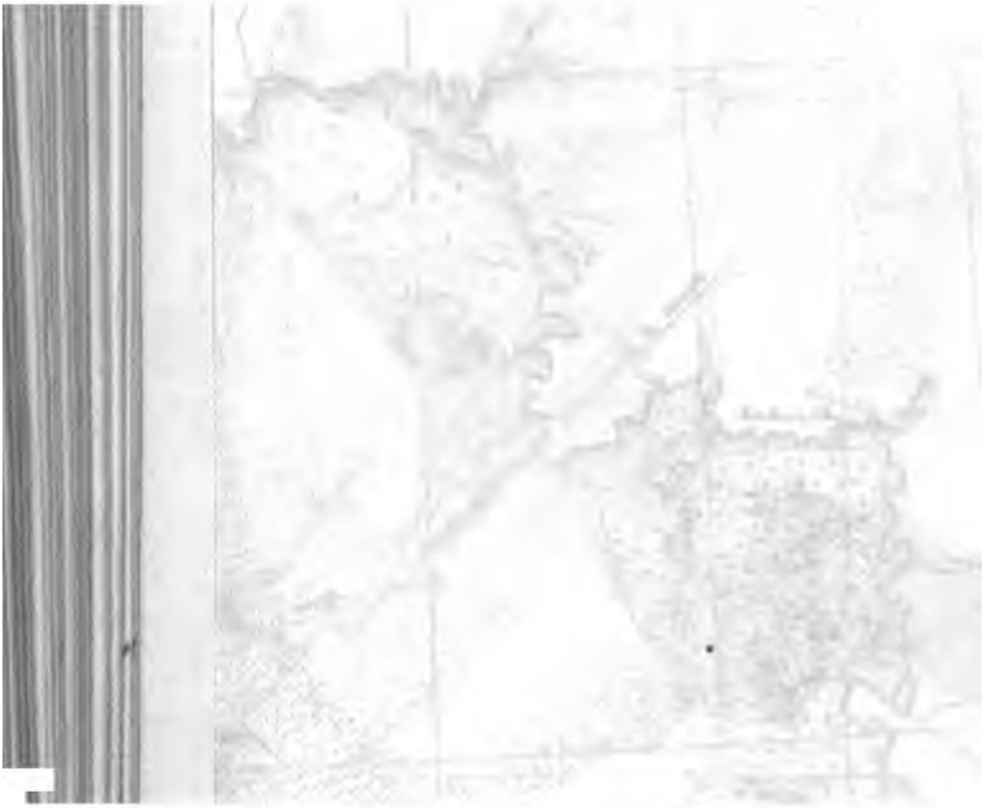
The metamorphic rocks of the eastern part of the region are divisible into two general groups—a schist group, derived chiefly from original sedimentary rocks, and a greenstone group, in which altered basic igneous rocks predominate.

The schist group outcrops at intervals along the Yukon from Kokrines nearly to Rampart and probably covers considerable areas in the adjacent territory north of the river. It also occupies a large area on the headwaters of Tozitna and Ray rivers that continues northeastward to the headwaters of Dall and Kanuti rivers.

The predominant rock types of the schist group are quartzite schists and quartz-mica schists. Associated with these rocks are limestones, augen gneisses, and greenstones, whose mechanical alteration is comparable with that of the predominant schist types. They are also cut locally by unsheared intrusive rocks.

The schist group is undoubtedly in large part the equivalent of the schist series on the headwaters of Dall and Kanuti rivers described


2°
South Fork
River
Ra
YUKON
a
40
152°



by Mendenhall[1] and considered by him to be of probable Devonian and Silurian age. The same physical characteristics have been noted in the rocks of the Ruby district to the southwest, where Devonian fossils were collected by the writer in 1912, and in the metamorphic rocks at the head of Little Minook Creek and on Quail Creek of the Rampart district, that have furnished Silurian and Devonian fossils. It seems probable that the group is composed chiefly of Silurian and Devonian terranes, though other Paleozoic periods may be represented.

The greenstone group forms the chief visible bedrock along the Yukon from a little below Rampart to Fort Hamlin and occupies a large area on both sides of the river. These rocks continue westward from the Yukon about 20 miles to the headwaters of Tozitna River. From this locality the western boundary swings to the northeastward and crosses the Yukon a little above Fort Hamlin. A published description[2] of this group as it occurs in the vicinity of Rampart is as follows:

> The greenstones proper are altered basic igneous rocks, principally diabasic flows and tuffs. Associated with them in the vicinity of Rampart are minor beds of slate, chert, and limestone, besides other igneous types. Among the latter are rhyolitic lavas and flow breccias and dense aphanitic laminated rocks that apparently include glassy lavas and fine-grained tuffs. The rhyolitic rocks occupy considerable areas to the exclusion of other types, their white or buff color contrasting strongly with that of the greenstones. At the head of Squaw Creek the sedimentary rocks are absent and reddish andesitic flows are interbedded with the greenstones. Throughout the area of the greenstones basic igneous dikes are common, but in the Squaw Creek locality they are especially abundant. In stratigraphic position the greenstones are apparently above the limestones and schists. The nature of their relation to the underlying rocks is not clear, but they seem to record a continuance of the same activities with a marked increase in volcanism. The lowermost greenstones are interbedded with marine sediments and were probably submarine flows. The absence of such sediments among the higher members suggests that either the accumulation of the lower beds or uplift brought the area above sea level and afterward igneous activities alone were recorded. The rate of accumulation of an igneous series is capable of such wide variation that it is obviously unsafe to designate any age as that witnessing the formation of all the greenstones. It seems likely that the formation of the lower members closely followed the Devonian sedimentation. They may represent only late Devonian activities or possibly some late Devonian and more or less of the succeeding age.

The greenstone group probably holds the same stratigraphic relation to the schists of the Yukon-Koyukuk region that it does to the limestone-schist group of the Rampart district, so that the discussion given of the age of the greenstones near Rampart is applicable to the group as a whole in the entire area of its occurrence.

---

[1] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers: U. S. Geol. Survey Prof. Paper 10, p. 32, 1902.

[2] Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U. S. Geol. Survey Bull. 535, pp. 18-19, 1913.

Mendenhall reports the occurrence of somewhat similar rocks in an area near the head of Kanuti River, which he describes, under the name Kanuti series, as a group of greenstones and fine-grained pyroclastics intruded by dioritic and gabbroic rocks and associated with compact and vesicular basalts and detrital volcanic rocks. The Kanuti "series" differs from the group under discussion in being made up predominantly of intrusive rocks and in having a greater range in the degrees of alteration to which its different members have been subjected. The two groups correspond in being of volcanic origin and it seems likely that they were formed at about the same time.

No other extensive areas of similar rocks are known in the Yukon-Koyukuk region, but their presence in parts of the region not yet visited is suggested by the occurrence of greenstone bowlders in the wash of Tozitna and Melozitna rivers.

MESOZOIC SEDIMENTARY ROCKS.

DISTRIBUTION.

Mesozoic sedimentary rocks comprise the visible bedrock of the entire region between Melozitna and Koyukuk rivers, excepting in the local areas occupied by granitic intrusions and the belts of indeterminate contact rocks surrounding them. Their eastern boundary follows the main course of the Melozitna for much of its length, but locally they extend for a short distance east of the river. North and west they extend beyond the field investigated.

STRATIGRAPHY.

These rocks comprise a sedimentary series of great thickness and of great diversity in the lithologic character of its members, which exhibit no available evidence of any notable stratigraphic break. A great number of formations, 50 to 300 feet thick, can be distinguished. The aggregate of the different recognizable members indicates that the thickness of the whole series is extraordinarily great. A complex structure, together with the limitations of a reconnaissance survey, prevented accurate measurements, but it seems clearly indicated that the series includes many thousand feet of beds.

The base of the series, where recognized, is a massive conglomerate of coarse texture. Locally, as near camp 41, it contains bowlders, of which the largest are 5 feet in longest dimension. The usual texture is not so coarse, the bowlders as a rule being about a foot in diameter. There is commonly a great discordance in size among the materials of the basal conglomerate, which suggests a marine origin. It probably was formed on a shore line that advanced by destroying pronounced sea cliffs.

The basal conglomerate is overlain conformably by finer beds—grits, sandstones, and shales. These beds may represent offshore deposits that were laid down contemporaneously with another part of the basal conglomerate a short distance away. Still higher in the series is an alternation of fine conglomerates and sandstones with more or less shale (now generally altered to the form of pencil shales and slates). The materials of the higher beds show better assortment as to size than the basal beds and in places have the bedded arrangement characteristic of stream deposits. Evidently the series was laid down in an area that was subject to intermittent subsidence. Now a marked subsidence gave marine conditions and again a period of stability permitted streams to build deltas and extend their flood-plain deposits out over areas that had just previously received marine sediments.

LITHOLOGIC CHARACTER.

The basal conglomerate is made up of bowlders of granite, gneiss, and a great variety of metamorphic rocks, such as occur generally in the region east of Melozitna River and probably form the floor on which the series rests.

The finer beds of the series include clays, shales, sandstones, grits, and fine conglomerates, the shales and sandstones predominating. The shales are generally dark-colored gritless sorts that have developed a slaty or pencil shale cleavage. Some are arenaceous and one important shale member has gravel scattered through it, singly or in thin lenses and strata. The sandstones are chiefly feldspathic and some approach a true arkose in composition. For the most part they contain a variety of materials, including quartz and feldspar grains, femic minerals, and fragments of chert, quartzite, and dense igneous rocks. These beds are the kind that would be formed by a greater comminution of the materials that enter into the basal conglomerate and point to continued sedimentation from the same sources.

STRUCTURE.

The series is massively bedded for the most part, but locally a close horizontal lamination is evident in the sandstone members and a strong cross-bedding in the fine conglomerates. The whole series has suffered extensive deformation. In general, a close irregular folding is indicated. Pronounced faults have developed in places, especially along Melozitna River at the eastern margin of the area. Locally, about the granitic intrusive areas, the beds are highly contorted and the original structures are entirely obscured. Pronounced secondary structures, including flow structures, schistosity, and slaty cleavage, have developed in these localities.

METAMORPHISM.

The granitic areas are surrounded by broad zones that are occupied by a peculiar assemblage of rocks whose origin and relationships are not entirely clear. In part they have the essential characteristics of basic lavas. Some are clearly altered Mesozoic sedimentary rocks and others contain much material derived from the magma that gave rise to the granitic rock in admixture with other material that came from the rocks which the magma invaded—probably from the Mesozoic rocks. This assemblage may be in part the rocks of an older group of strata than the typical unaltered Mesozoic beds (that are generally without igneous members), which have been exposed by erosion in local anticlines produced by the intrusion of the granites. Or it may be that the granitic intrusions coincided in position with locally developed volcanic members in the Mesozoic succession. However, as many of the rocks more or less characteristic of the whole assemblage are known to have been derived from the Mesozoic sedimentary rocks, and as locally the evidence of extensive igneous metamorphism is conclusive, it seems to the writer that these rocks are best interpreted as having developed from the Mesozoic sedimentary rocks through the metamorphic influences that attended their invasion by the granitic magma.

The metamorphism attending the granitic intrusions is illustrated in the present condition of a fine even-grained quartz conglomerate bed that abuts against the granite area west of the head of Pocahontas Creek. Near the contact the conglomerate is reduced to a solid mass of quartz in which structure and the original form of pebbles have been effaced. This condition holds for over a hundred feet. Beyond this the pebble forms may be more or less clearly distinguished. A pronounced induration and silicification extends for more than a mile from the contact. Flow structure is developed in places and the addition of magmatic material is seen near the contact. The impure sedimentary beds associated with the conglomerate are profoundly altered for a mile or more from their contact with the granites, and for the most part have taken on an igneous appearance generally characteristic of the rocks of this group. As the rocks of the whole assemblage are considered to be analogous to the metamorphosed beds associated with the conglomerate, they are grouped together in mapping under the head of contact rocks, and no attempt is made to distinguish between various members of the group that may differ considerably as to the details of their genesis.

The contact rocks are for the most part dark or greenish in color, entirely dense or porphyritic, with a dense groundmass, and are very hard and resistant to weathering. In the least altered phases of the *typical* arkose of the sedimentary series there is a partial isolation of the coarser quartz and feldspar grains by the development of a glassy or finely crystalline matrix. In more altered phases the matrix is developed in relatively greater volume, the quartz and feldspar grains are more completely isolated, and the quartz grains show marked corrosion. A gradation exists in which the quartz grains approach complete resorption and the recrystallized or glassy matrix is developed in progressively greater quantities. In still more advanced phases of alteration the more acidic of the feldspars are more or less resorbed and secondary basic feldspars are developed. The porphyritic appearance of these rocks is due in part to the resistance of basic feldspars original in the arkose, in part to the development of secondary feldspars, and in part to masses of epidote and chlorite that have replaced some of the original grains, the principal mass of the rock having been reduced to a glassy or finely crystalline condition. Near the granitic areas the magma probably contributed much of the material of the contact rocks. Here femic minerals are abundant and there are phases that differ from the typical granites only in the relative abundance of their common constituents. Apparently there are gradations of the contact rocks into the granites on the one hand and into the sedimentary rocks on the other. The more siliceous sandstones have been altered to quartzite and the shales have been indurated or vitrified and partly recrystallized.

AGE AND CORRELATION.

No fossils have been found in the sedimentary series in the Yukon Koyukuk region. The character of the series at a distance from the problematic contact rocks and its distribution indicate close relationships with the Shaktolik group of the Nulato-Norton Bay region, of known Upper Cretaceous age, and with the Bergman group of the upper Koyukuk basin which has been correlated with the Shaktolik group. It is quite probable that these beds furnish a continuation of contemporaneous strata northeastward from the Shaktolik area through the Yukon-Koyukuk region into the upper Koyukuk basin, which strengthens the correlation between the Bergman and Shaktolik groups.

Lower Cretaceous fossils were collected by Schrader[1] from a pinkish limestone, which is associated with igneous amygdaloidal and andesitic tuffs on the west bank of the Koyukuk a few miles below Hughes. No rocks of this character were noted by the writer south of the Koyukuk, unless possibly they are included among the apparently igneous members of the so-called contact rocks. There is no evidence of a stratigraphic break between the contact rocks and the normal rocks of the Shaktolik and Bergman type, such as generally exists

---

[1] Schrader, F. C., Preliminary report on a reconnaissance along the Chandlar and Koyukuk rivers, Alaska, in 1899: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, p. 477, 1900.

between the Lower Cretaceous and Upper Cretaceous series in Alaska. Unless the series are conformable in this part of Alaska the presence of Lower Cretaceous strata in the region south of the Koyukuk is improbable. If they are present conformably below the Upper Cretaceous, much more extended and detailed work will be required to distinguish them and outline their areal distribution.

TERTIARY ROCKS.

Small isolated areas of Tertiary sedimentary rocks occur on Dall and Ray rivers and at a number of localities along Yukon River. The beds include clays, shales, sandstones, conglomerates, and thin lignitic seams, and are apparently of fluviatile origin, the coal beds representing vegetal accumulations in the lateral basins of aggrading Tertiary streams. There is a close accordance in their composition and physical condition in all the areas and they are probably of the same age. Fossils that were collected from the area near Rampart have been determined as younger than the Kenai flora of Cook Inlet.

QUATERNARY DEPOSITS.

Quaternary deposits mantle a large part of the Yukon-Koyukuk region. They include moraines and glacial outwash deposits, lacustrine silts and beach gravels, and the alluvial deposits of lowland plains and modern flood plains.

The glacial deposits are found chiefly in the valleys that head in the Ray Mountains. These valleys show many well-developed transverse moraines, some of which are more than 20 miles below the heads of the valleys in which they lie. Beyond the lowermost moraine the valleys are commonly walled by outwash deposits in which the postglacial streams have entrenched themselves. In the reaches that traverse the outwash deposits the valleys are broadly V-shaped—a form that is in marked contrast with the glaciated headward parts of the same valleys.

A few small moraines occur in the glaciated part of the Yukon-Melozi divide and at a locality a few miles northwest of Melozitna Canyon, but the material involved in them is insignificant in amount. Lacustrine silts are extensively developed in many parts of the region. They fill an erosional depression at the lower end of the Yukon Flats that represents a northeastward continuation of the valley of Ray River. The present topography of the lower parts of the basins of Ray and Dall rivers is carved largely in silt deposits. Similar deposits also fill the abandoned valley through which Indian River formerly flowed to the northeast and are exposed at places in the bluffs along the Yukon and Koyukuk rivers and many of their tributaries. The general distribution of the lacustrine silts is what would be expected if they had once prevailed over the entire region up to an elevation at least several hundred feet above that of the major streams and had since been partly removed by erosion.

Gravel terraces and probable wave-cut terraces and wave-flattened ridges have been noted in many parts of the region, particularly in the basins of Ray, Dall, and Melozitna rivers and along the Yukon in the vicinity of the Ramparts. In the basins of Ray and Dall rivers and along the Yukon these features have their chief development at an elevation of about 1,500 feet above sea level. Farther down the Yukon and in Melozi River basin they are probably most strongly developed at less elevation.

Lowland plains occupy large areas bordering on Yukon and Koyukuk rivers and in the basins of many of their tributaries. They have resulted from the aggradation of the valleys of an antecedent drainage system whose arrangement was considerably different from the present. The materials of the lowland plains have probably been brought to place chiefly by streams, but in places glacial deposits and lacustrine silts are included. The flood plains of the present streams are nowhere much wider than the meander belts of the streams that traverse them. They are even narrower where the streams have recently entrenched themselves and in places are absent, as in the Ramparts of the Yukon and the canyons of Melozitna, Kanuti, and Indian rivers.

IGNEOUS ROCKS.

The igneous rocks of the region are of three general types: The greenstones, the altered, and the unaltered granitic intrusions. This order expresses the apparent age relations of the different types, beginning with the oldest, and will be followed in further discussion. The greenstones have already been described in connection with the Paleozoic metamorphic rocks. Another rock type of doubtful origin, having the essential characteristics of basic lavas, has been discussed on a preceding page in connection with the contact rocks that surround the late intrusions in the Mesozoic area west of Melozitna River.

ALTERED GRANITIC INTRUSIVES.

Altered granitic intrusives occur in many places in the eastern half of the region that is occupied chiefly by Paleozoic metamorphic rocks. Their present forms include gneisses, augen gneisses, and sericite schists. They occupy large individual areas for the most part, but there are many long and relatively narrow areas that may represent granitic dikes or sills intruded into the Paleozoic rocks before their principal alteration took place. Schists and augen gneisses are characteristically developed at the margin of the great granitic areas of the Ray Mountains and in the prominent mountain range along the Yukon southwest from the vicinity of Tozitna River. Gneissoid rocks penetrate the other granitic bodies, and in many places a complex relationship exists between the sheared and unsheared types that could be shown only on a map of much larger scale and after extensive detailed study. The gneisses are plainly derived from igneous rocks. The origin of the schists is less easily determined. There is a gradation between gneiss and schist in places that indicates their equivalency, though there are schists of like character in many parts of the field which may be igneous derivatives but whose origin is still uncertain.

The more highly altered granitic derivatives have about the same degree of metamorphism as the Paleozoic sedimentary rocks. The exact age of the metamorphism of the Paleozoic rocks is unknown, but it was probably in late Paleozoic time. The oldest of the granitic derivatives may have been intruded in Paleozoic time. If the degree of alteration is a criterion of age there must have been a succession of intrusions during later ages, for there is a gradation of the altered granites from schistose forms through the whole range of gneissic development.

UNALTERED GRANITIC ROCKS.

Unaltered granitic rocks occur in all parts of the region, cutting both Paleozoic and Mesozoic terranes. They are developed chiefly as huge batholiths and thick lenses. The largest areas comprise one in the Ray Mountains and one between the Melozitna and Tozitna rivers. It is not unlikely that these areas will be found to merge when their extents are fully known. Elsewhere in the region the granitic bodies have thick lenticular forms. But few thin dikes or sills were noted.

The unsheared granites of the western part of the region cut strata of probable Upper Cretaceous age. Those near the Ramparts of the Yukon are closely analogous to granitic intrusives of the Yukon-Tanana region, which in places cut Upper Cretaceous rocks. However, the basal conglomerate of the sedimentary series along the Melozitna contains bowlders of unsheared granites. Evidently the unsheared granites include rocks both older and younger than Upper Cretaceous and it is not unlikely that they represent a considerably greater range in age than the bare limits of this period. In connection with the granitic derivatives the unsheared granites suggest a period of intermittent intrusion, extending from some Paleozoic age possibly into the Tertiary.

MINERAL RESOURCES.

PROSPECTS.

Placer gold is apparently widely distributed in the Yukon-Koyukuk region, but the deposits have thus far shown little economic importance. Gold prospects have been found on a number of northern tributaries of the Yukon from Morelock Creek westward to Melozitna

River. A little desultory mining has been done on Morelock and Grant creeks, but the production from this whole section of the region has been negligible. Active placer mining on a small scale has been in progress since 1911 on Indian River in the northern part of the region. A little gold has also been recovered from the south bank of the Koyukuk at a place called Red Mountain a few miles above Hughes. Gold is said to occur also on some of the southern tributaries of the Koyukuk below Indian River.

There are no gold lode mines in the region and but a single prospect. This prospect is on the north side of the Yukon near the bank, about 20 miles below Tanana, and has the distinction of being the first attempt to open a lode mine in the interior of Alaska. It was opened about 1890, but was abandoned soon afterward.

A silver-lead prospect has been opened on the west side of the Yukon near Morelock Creek. This prospect is described by prospectors as a close stockwork about 10 feet wide. Large pieces of nearly pure galena from this locality were shown the writer at Rampart in 1912, and it was stated that the ore contained considerable silver and a little gold. No quantitative analysis of the ore is known to have been made and the economic value of the deposit is uncertain.

INDIAN RIVER GOLD PLACERS.

The gold placers of Indian River are all on the main northern headwater stream from 3 to 5 miles below its source. More or less mining has been done on 13 different claims, but the profitable placers are restricted to five or six claims. A little gold has been recovered also from Black Creek, a southern tributary of Indian River above the workings.

The gold-bearing deposits of Indian River are almost entirely in the immediate bed of the stream. At one place the pay streak is under the east bank of the stream for a short distance, but the deposit is on a level with the stream and does not indicate a true bench deposit.

The auriferous gravels are 2 to 6 feet deep and have an average width of about 50 feet. The bedrock throughout the area of profitable placer ground is granite and the deposit is made up chiefly of granite sands and residual bowlders from local sources. The bowlders are a product of concentric weathering in the granite rather than of water wear. They have been concentrated in the stream bed by the flow of waste from the hillsides under frost action and the removal of the finer materials by the stream. The bowlders make up most of the deposits and are a hindrance to economic mining.

Gold was first discovered on Indian River in 1909 by a native. He gave information of his discovery to J. C. Felix, a white prospector, who visited the locality in 1910 and struck pay dirt late in the summer. The summer of 1911 witnessed the first actual mining in the district, when four claims were worked by 10 men and nearly $10,000 worth of dust was produced.

In 1912 seven claims were worked by about 20 men, with a reported production of $24,500.

In 1913 work was being done on 13 different claims by about 35 men. Little besides prospecting was accomplished, however, until late in the summer, as the stream was almost dry on account of the prolonged drought. Up to July 24 only $8,700 had been produced. Work later in the summer was more successful and a total production of $31,952 was reported for the season.

PLACER MINING ON SEWARD PENINSULA.

By Theodore Chapin.

INTRODUCTION.

The placer-mining industry of Seward Peninsula suffered a general depression in 1913. The value of the gold produced is estimated to be $2,500,000; in 1912 it was $3,025,000. There has been a general decrease each year since 1906, when the output was valued at $7,500,000, to the present year. This is the natural history of a rich placer camp and is due to the facts that the bonanzas are being gradually worked out and that the present output is won largely from gravels of lower grade. The decrease in production in 1913, however, was due in large part to the drought which affected every mining district of the peninsula to a greater or less extent. The past tendency to ascribe any reduction in the gold output of Seward Peninsula to a lack of rain may give this statement a familiar ring, but in this instance the facts justify the statement. From June to late in September practically no rain fell; many of the creeks which usually supply water for mining were absolutely dry, and others were low.

DREDGING.

Dredging is less affected by scarcity of water than other forms of mining, but even the dredge operations were hampered, for many dredgers had to dig into bedrock or construct dams to get water sufficient for flotation. Dredging has become an established method in the mining industry of Seward Peninsula. In 1913 there were 31 gold dredges and one tin dredge operating, with a combined daily capacity of 33,000 cubic yards. It is estimated that during the season they moved 3,500,000 cubic yards of gravel. Four new dredges were installed in 1913 and several were in course of construction, and others which are contemplated will be erected in the near future. Besides those in operation in 1913 there were six temporarily idle.

Dredges are now working in every mining district of Seward Peninsula. This geographic distribution and the fact that they are successfully used to dig deposits of various kinds, including the shallow stream gravels such as are found on Solomon River and the deep gravels of the coastal plain, show their adaptability to the various conditions met in the peninsula.

The average length of the dredging season in the southern part of Seward Peninsula in a normal year is about 120 days. This figure is based on the actual working season of the successful dredges which work through the season without mishap. By efficient management the dredging season might be lengthened, for a number of dredges work 140 days and one operator claims a season of six months. On Solomon River the season about equals the general average of 120 days. In Nome it is a little longer, and in Council a few days less. The average season in the Fairhaven region is a little shorter than on the southern coast. Steam dredges have a longer average working season than those equipped with internal-combustion engines.

Among the dredges recently constructed in Seward Peninsula flume dredges appear to predominate. That the gold-saving efficiency of the flume dredge is as great as that of a stacker dredge with its greater table area is doubted; however, it has advantages that recommend it for working certain deposits. It can be more easily moved and can be used on shallow gravels where it would be necessary with a larger dredge to dam or to dig bedrock to get flotation.

Most of the dredges of the Seward Peninsula burn distillate. A comparison between the operating costs per cubic yard of dredges burning crude oil and those burning distillate shows little advantage to either fuel, but the working cost of the machines burning wood and coal compares favorably with those burning fuel oils.

A list of the dredges on Seward Peninsula is given in the accompanying table:

Dredges on Seward Peninsula, 1913.

Company.	Location of dredge.	Built.	Type or builder.	Size of buckets (cubic feet).	Bucket line.	Source of power.	Fuel used a day.	Horsepower.	Average daily capacity (cubic yards).
NOME REGION.									
Nome Consolidated Dredging Co.	Bourbon Creek	1908	Reconstructed	10	Close	Electricity		275	2,100
Do	Wonder Creek	1908	do	7	do	do		275	1,400
Do.[a]	do		American Manganese Steel Co.	10	do	do			
Ernst Alaska Gold Dredging Co.	Rocker Gulch	1912	Flume; American Dredge Building & Construction Co.	1½	Open	Distillate	75 gallons	40	500
American Gold Dredging Co.	Peluk Creek	1913	do	1½	Close	do	100 gallons	50	1,000
Plein Mining & Dredging Co.	Otter Creek	1910	Risdon	3½	Open	Crude oil	13 barrels	130	800
Julien Gold Mining & Dredging Co.	Osborn Creek	1911	Union Construction Co.	2½	do	Distillate	140 gallons	85	800
Gold Beach Dredging Co.[b]	do	1905	Reconstructed I. B. Hammond	5	do	Crude oil	30 barrels	165	1,000
Saunders Creek Dredging Co.[b]	Saunders Creek	1910	Bucyrus	3½	Close	Distillate	300 gallons	122	2,000
Sioux-Alaska Mining Co.[b]	Moss Gulch	1910	Northern Construction Co.	2½	Open	do	160 gallons	85	750
Nome Gold Gravel Co.[a]	Cripple River		E. L. Smith	10	do	Crude oil		75	
Arctic Gold Dredging Co.	Hobson Creek	1910	Union Construction Co.	2¼	do	Distillate	120 gallons	92	750
Bessie Gold Dredging Co.[a]	Holyoke Creek		E. L. Smith	9	Close				
SOLOMON REGION.									
Nome, Montana & New Mexico Consolidated Mining Co.	Solomon River	1907	Risdon	5	Open	Coal	4½ tons	120	1,600
Seward Dredging Co.	do	1905	West Engineering Co.; Bucyrus machinery.	5	Close	Crude oil	42 barrels	200	2,000
C. E. Kimball	Shovel Creek	1911	Flume; Flume Dredge Co.	3	Open	Distillate	115 gallons	60	1,100
Shovel Creek Gold Dredging Co.	do	1912	Yuba Construction Co.	2¼	Close	do	200 gallons	120	833
Sivertsen & Johnsen Mining & Dredging Co.	Solomon River	1900	I. B. Hammond	1½	Open	do	50 gallons	22	300
Do	do	1910	Risdon	2¼	do	Crude oil	15 barrels	65	800
Flodin Gold Mining & Dredging Co.	do	1910	do	2¼	do	do	13 barrels	75	1,000
Do	do	1912	Flume; Flume Dredge Co.	2½	do	Distillate	112 gallons	60	900
Solomon Dredging Co.	do	1910	Bucyrus	3½	Close	Crude oil	25 barrels	140	1,650
CASADEPAGA REGION.									
Ruby Dredging Co.	Casadepaga River	1912	Flume; Union Construction Co.	2½	Open	Distillate	130 gallons	90	800
Willow Dredging Co.[c]	Willow Creek	1910	Union Iron Works	3	do	do	140 gallons	95	600
Nome, Montana & New Mexico Consolidated Mining Co.[d]	Goose Creek	1909	Reconstructed Byron Jackson	2¼	do	do	110 gallons	65	800
Oro Dredging Co.[e]	do	1909	Flume; reconstructed Bernard	1½	do	do	40 gallons	18	500

[a] Under construction.
[b] Not in operation in 1913.
[c] Formerly Casadepaga Gold Dredging Co.
[d] Formerly Goldbottom Dredging Co.
[e] Formerly Goose Creek dredge. Will be operated on Elkhorn Creek in 1914.

Dredges on Seward Peninsula, 1913—Continued.

Company.	Location of dredge.	Built.	Type or builder.	Size of buckets (cubic feet).	Bucket line.	Source of power.	Fuel used a day.	Horsepower.	Average daily capacity (cubic yards).
COUNCIL REGION.									
Blue Goose Mining Co.	Ophir Creek	1903	Reconstructed Hammond	3	Close	Wood	9 cords	94	1,600
Wild Goose Mining & Trading Co.	do	1910	Yuba Construction Co.	3½	do	Distillate	300 gallons	140	1,800
Flume Dredge Co.[a]	do	1910	Flume; Flume Dredge Co.	2½	Open	do	115 gallons	60	800
Do.	Melsing Creek	1913	do	2½	do	do	do	60	800
Star Dredging Co.	Mystery Creek	1911	Flume; Union Iron Works	2½	do	do	110 gallons	70	1,000
Warm Creek Dredging Co.	Warm Creek	1909	Byron Jackson	2½	do	do	85 gallons	65	1,000
FAIRHAVEN REGION.									
Candle Creek Mining Co.	Candle Creek	1912	Flume; Union Construction Co.	1¾	Open	Distillate	120 gallons	50	600
Kugruk dredge	Kugruk River	1913	do	3¾	Close	do	225 gallons	107	1,000
Inmachuk Gold Dredging Co.	Inmachuk River	1912	do	3	Open	do	210 gallons	100	900
Deering Dredging & Mining Co.[b]	do	1912	American Dredge Building & Construction Co.	2	do	do	112 gallons	50	1,000
KOUGAROK REGION.									
Alaska-Kougarok Dredging Co.[b]	Kougarok River	1912	Risdon	2½	Open	Distillate	200 gallons	80	600
PORT CLARENCE REGION.									
Flodin & Hutton[c]	Dick Creek		Flume; Union Construction Co.	2½	Open	Distillate			
Pasadena Gold Dredging Co.	Budd Creek	1912	do	2¾	do	do	190 gallons	100	800
Anglo-American Gold Dredging Corporation.	Sunset Creek	1913	Flume; American Dredge Building & Construction Co.	2	do	do	110 gallons	50	500
York Dredging Co.[d]	Buck Creek	1911	Flume; Union Construction Co.	2¾	do	do	165 gallons	87	800

[a] Formerly Kimball & Saupe.

[b] Formerly Kelliher dredge.

[c] Under construction.

[d] Tin dredge.

OPERATIONS IN DETAIL.

NOME REGIO[illegible]

In the vicinity of Nome placer mining was attempted on nearly all the producing creeks, but the operations were seriously hampered by lack of water.

The hydraulic plants of the Pioneer Mining Co. on Specimen Gulch and Anvil and Little creeks and of the Wild Goose Mining & Trading Co. on Cooper Gulch were worked intermittently during the summer whenever water was sufficient, but were idle much of the time. Hydraulic outfits were also mining on Bowlder, Balto, and Osborn creeks.

Considerable activity was shown in drift mining in the winter of 1912–13. On Dexter Creek nine plants took out winter dumps, but only three attempted to sluice. Water was so scarce that one outfit used a rocker washing with seepage water. A number of large plants worked in the deep mines on the coastal plain. A very rich strike is reported from the Golden Cow claim, on the ridge between Otter and Dry creeks, about 3 miles northeast of Nome. In October, 1913, this claim was being prospected to prove the extent of the pay streak. Another promising strike was made on Manila Creek, a tributary of Hobson Creek. Prospecting revealed very rich gravel on schist bedrock about 25 feet below the surface. The gold is coarse and flaky. The pay streak is narrow but is said to be about 10 feet thick. Its length has not been determined.

The Nome Consolidated Dredging Co. operates two large dredges and is building a third. The dredges are working on Bourbon and Wonder creeks in the coastal-plain gravels. The Bourbon dredge is successfully working a deposit over 70 feet thick and is digging 52 feet below the water level. Both are driven by electricity generated at a central power plant on Bourbon Creek. Crude oil is used for fuel.

The hull of the new dredge being built on Wonder Creek was nearing completion in the fall of 1913, and the machinery was to be taken in on the ice during the winter.

Two dredges operated on the Nome beach in 1913. The Ernst Alaska Gold Dredging Co. is working a narrow strip of ground at the mouth of Rocker Gulch on the beach just below the frozen tundra-covered coastal plain.

The Bernard dredge was worked for a part of the summer by the American Gold Dredging Co. on the beach at the mouth of Peluk Creek. This is a flume dredge. The first two boxes are fitted with Hungarian riffles, and below these every other box has wire screen with cocoa matting beneath and the alternate ones contain iron-bar riffles. A perforated plate at the end of the flume leads to the under-current sluice. Water is pumped by a 10-inch centrifugal pump. The dredge started 150 [illegible]t above the high-water mark and planned to work to the water's edge, leaving a wide cut for a place of rapid retreat in case of storm. A cut 100 feet wide was made, 2 to 3 feet of gravel being taken off with each swing of the dredge, and the cut being gradually deepened to a false bedrock of clay 15 feet below the surface.

The Plein dredge is working on Otter Creek near its mouth. The company controls 1,300 acres of ground, including 500 acres on Nome River. In 1913 the dredge was digging just below the supposed end of the second beach line. It appears also to be on a submarine beach, for the bedrock on which the dredge was digging is 12 feet below sea level. Thawing is necessary except along the present stream channel.

The dredge of the Arctic Gold Dredging Co. on Saunders Creek was dismantled and the machinery placed on a new hull built on Hobson Creek. The dredge was placed at the upper end of the dredging ground and is working downstream. This causes considerable dead work, as the gradient of the stream is steeper than is generally considered feasible for dredging, so that it is necessary to build a dam every 150 feet. It is thought that on the lower part of the stream damming will not be necessary.

The dredge of the Julien Gold Mining & Dredging Co. began working on Osborn Creek about the middle of June. The old dredge of the Gold Beach Dredging Co. on Osborn Creek sunk last winter and was sold to J. H. Montgomery.

The Saunders Creek Dredging Co. has worked out its ground on Saunders Creek and is prospecting new ground. No mining was done in 1913. The Sioux Alaska Mining Co.'s dredge on Moss Gulch was also idle in 1913.

The Bessie Gold Dredging Co. is building a large dredge on Holyoke Creek. The dredge of the Nome Gold Gravel Co. on Cripple River is expected to be in operation in 1914.

SOLOMON RIVER BASIN.

Little work was done on Solomon River in 1913 outside of dredging. Three hydraulic plants were in operation during part of the season and about 20 men were sluicing whenever water was adequate. The Seward Dredging Co. worked a hydraulic plant on Shovel Creek and took out two pits aggregating about 8,000 cubic yards. One man was sluicing on Kasson Creek, a tributary of Shovel Creek. An outfit with a horse scraper worked for a month and a half on Big Hurrah Creek, and a little work was also done on Penny Creek, Rock Creek, and Moran Gulch. No mining is being done on East Fork at present, but considerable prospecting has been carried on to determine possible dredging ground.

Nine dredges operated on Solomon River and Shovel Creek, and all report a fairly successful season. Th[illegible]dge of the Shovel Creek Gold Dredging Co. was installed in 19[illegible]nd operated for six weeks. Considerable difficulty was experienced with low water, as the gravel is only 3 to 4 feet deep, so that it is necessary to dig bedrock or dam the stream to get sufficient water for flotation. The gold collects in the limestone bedrock and it is necessary to dig 2 feet of the broken rock. The flat above the dredge has been prospected by drilling.

The Mulligan dredge on Shovel Creek has not been in operation for two years. It is a stationary land dredge and can be moved on light railroad rails. It turns on a circular track 12 feet in diameter and is equipped with open-connected 1-foot cylindrical buckets. The gravels are washed in a flume above the body of the dredge. A small gasoline engine furnishes power to run the bucket line and to pump water. Three claims at the mouth of West Creek were worked out with this machine, which was then abandoned. Dredges of this type may yet be found to be well adapted for working very shallow deposits where water is not sufficient to float a boat dredge.

The Kimball dredge is digging near the mouth of Shovel Creek. The dredges of the Seward Dredging Co. and the Nome, Montana & New Mexico Consolidated Mining Co. are working on Solomon River near the mouth of Shovel Creek. Four other dredges are digging on Solomon River between this point and East Fork—two belonging to the Flodin Gold Mining & Dredging Co. and two to Sivertsen & Johnsen. The dredge of the Solomon Dredging Co. is on Solomon River near the mouth of Butte Creek. The gravel at this place is from 4 to 8 feet thick. In the spring the ground is partly frozen, but no artificial thawing is necessary. The equipment of this dredge was recently changed from coal to oil burning engines, effecting a considerable saving. The Seward dredge is not working in the river channel proper but in the bench deposits, where it is necessary to thaw the ground in advance of the dredge.

BLUFF REGION.

Little work was in progress at Bluff in 1913. One man was working a bench deposit near the beach by pumping sea water. No water was turned into the Topkok ditch.

COUNCIL REGION.

The Council output was derived essentially from the dredges. Winter work was done at only one plant, which employed three men. In the summer 125 men were mining on 23 claims. Six dredges were in operation during the greater part of the summer. Three of these were on Ophir Creek, which continues to be the principal producer. The pioneer dredge of the district is the *Blue Goose,* which was installed in 1903. This dredge was recently overhauled and a 5-foot open-connected bucket line changed to a 3-foot close-connected line, resulting in an increased efficiency. The dredge of the Wild Goose Mining & Trading Co., also on Ophir Creek, is the largest producer of the district. The other Ophir Creek boat is the flume dredge which for a time was operated on Melsing Creek.

Another dredge was installed by the Flume Dredge Co. on Melsing Creek late in the season of 1913 and ran for about two months.

The dredge of the Star Dredging Co. has been working on Mystery Creek 3 miles from the mouth of the creek and 4 miles northeast of Council City. The gravels are from 2 to 15 feet thick and overlie a clay false bedrock where much of the gold is found. The dredge has a 60-foot flume, 5 feet wide. The upper 15 feet is fitted with railroad iron set longitudinally, and the rest of the flume has Hungarian riffles. The buckets dump into a hopper and the gravel falls on a grizzly, through which the water for sluicing is forced from below. This spout of water and a gate of iron bars in the sluice box are designed to break up the clay, but are ineffectual, as it is necessary to keep a sluiceman constantly forking disintegrated material in the flume. The dredge was recently sold and will be moved to new ground.

The Warm Creek dredge had a fairly successful season, considering the lack of water.

Besides the dredges, several other large plants and a number of smaller ones were in operation. Possibly 30 men, aside from those employed on the dredges, were mining on Ophir Creek. Three hydraulic plants worked part of the season and several men were sluicing. At the mouth of Melsing Creek a plant which was mining a bench deposit took out one pit with a steam scraper, but was forced to quit for lack of water. Mining was also done on Crooked, Dutch, Sweetcake, Elkhorn, and Camp creeks.

On I X L Gulch, a tributary of Fox River, one man mined on a small scale. The supply of water obtained by impounding the flow from springs was sufficient to sluice for a few hours at a time. Little work has been done here, but considerable ground has been prospected and is being held for hydraulicking or dredging.

CASADEPAGA RIVER BASIN.

The Ruby Dredging Co., working on the Casadepaga near the mouth of Ruby Creek, experienced considerable difficulty with large bowlders, but otherwise had a successful season. The property of the Casadepaga Gold Dredging Co. on lower Willow Creek was recently transferred to the Willow Dredging Co. Water was so low on the creek that it was necessary to cease operations soon after the first hard freeze.

On Willow Creek above the dredge one hydraulic plant employed four men, and several men were sluicing. No mining was being done on Ruby Creek, but assessment work is kept up on claims that are being held for dredging ground.

Two dredges were idle on Goose Creek, as there was not sufficient water to run. One of these, which was locally called the *Goldbottom* dredge, has been bought by the Nome, Montana & New Mexico Consolidated Mining Co., and will be operated in 1914. The Goose Creek dredge has been purchased by the Oro Dredging Co. It will be remodeled and moved to Elkhorn Creek, where it is to be operated in 1914.

IRON CREEK REGION.

More mining was being done on Iron Creek and tributaries in 1913 than for several years. From 70 to 80 men were at work sluicing and prospecting. Water was sufficient to work the creek claims. On Sherette Creek one outfit employed five men to do assessment work.

PORT CLARENCE PRECINCT.

In the Port Clarence precinct about 125 men worked a greater part of the summer, but some of them were engaged in construction work. A dredge was installed on Sunset Creek and worked over three months with good results. In the main it worked in thawed ground, but points of frozen gravel which project into the river will have to be thawed before they can be worked. This will be done by stripping and steam pointing. The bedrock consists of greenstone schist and limestone and contains so much gold in the crevices that it is necessary to remove about 3 feet of the rock. A cut 300 feet wide includes two pay streaks and intermediate areas containing more or less gold. Plans are being made for the installation of another dredge on Sunset Creek in the near future.

The Johnstone dredge was operated on Budd Creek near the mouth of Windy Creek for 23 days. It was necessary to work through much barren ground to get to pay gravel, and then some difficulty was experienced with frozen ground. It will be necessary either to strip the ground and allow it to thaw or to thaw it artificially. This dredge was built in 1912 and was run 30 days.

The tin dredge on Buck Creek, in the York district, ran only six weeks and closed for lack of water.

A dredge was taken to Dick Creek, a tributary of Serpentine River, by Flodin & Hutton, but was not installed, as no ground has been prepared for dredging.

Sullivan & Dobson prospected American River for the Budd Creek Gold Dredging Co. They plan to install a dredge in the near future.

KOUGAROK REGION.

In the Kougarok region the drought was severely felt. About 75 men worked part of the season, but all work was curtailed by lack of sufficient water during the entire season and by the early freeze-up. By the middle of September few plants were still in operation.

Dahl Creek was nearly dry. Four outfits tried to sluice, but had sufficient water to work only one claim at a time. Two men worked on Coffee Creek. Quartz Creek was dry, but one man performed a little dead work. No work was done on Windy and Coarse Gold creeks. At the mouth of Little Windy Creek considerable prospecting was done but no sluicing. The ground is being held for dredging. Two outfits mined on the North Fork.

The Wall Real Estate Corporation, owner of the North Star Ditch, was prepared for extensive operations, but could do little mining. Near Taylor Creek a hydraulic elevator was run for 10 days. At this place the river has been turned into a new channel and the old channel will be mined. This company intends to install a dredge in the near future.

A claim near the mouth of Dreamy Gulch was ground-sluiced, and a winter dump which was obtained by drifting beneath the river was partly worked. Two outfits mined on Kougarok River between Taylor and Macklin creeks. Five outfits employing about 15 men were at work on Macklin Creek. George James was constructing a ditch to take water from Schlitz Creek, on Serpentine River, to Macklin Creek.

The dredge of the Alaska-Kougarok Dredging Co., locally known as the Kelliher dredge, is digging on Kougarok River above Macklin Creek. The company is said to own a mile of dredging ground along the river, consisting of a broad flat 600 feet wide. The dredge has cut one strip 100 feet wide for 2,500 feet along the river and has started to make a parallel cut in the adjoining area, which has been artificially thawed. The thawing is accomplished by ground-sluicing off a foot and a half of moss and muck, which overlies a layer of frozen muck and lenses of clear ice. This material is in part broken by blasting and then thaws naturally by exposure to the sun and air. Water for sluicing is obtained by two ditches, one to Trinity Creek and one to Columbia Creek. The latter was recently cut and will be finished in another season.

Above the Kelliher dredge three outfits mined from June until September.

FAIRHAVEN DISTRICT.

In the Fairhaven district four dredges were in operation in 1913, and each had a fairly successful season. One of these was on Candle Creek, one on the Kugruk, and two on Inmachuk River. The

Kugruk dredge was installed in 1913 and operated for about a month and a half. Other dredges which are planned for this region may be installed in the near future. Representatives of the Dearborn Investment Co. extensively prospected the company's holdings on Kugruk River last season and expect to install a dredge in 1914. It is also reported that another company will put a dredge on Independence Creek, a tributary of the Kugruk.

The Keewalik Mining Co. on Candle Creek employed 25 men during the spring and 15 in the summer, but work was confined principally to dead work, as there was little water for mining. Several large plants were sluicing, but the output was small. On the Inmachuk the Fairhaven Ditch & Water Co. employed about 100 men. The winter output of 1912–13 was exceptionally small, owing in part to a shortage of coal.

LODE DEVELOPMENTS ON SEWARD PENINSULA.

By Theodore Chapin.

GENERAL CONDITIONS.

During the later part of the summer of 1913 a few of the lodes in the vicinity of Nome were visited and information was gathered regarding development of lodes in other parts of Seward Peninsula.

The only metals being commercially extracted from bedrock on Seward Peninsula are tin and tungsten. The development of these lodes, the erection of a test mill, and the production of nearly 5,000 pounds of concentrates of tin and tungsten constitute the most notable achievement of the year in lode mining in Seward Peninsula. Lodes bearing gold and silver have produced ore in the past, and although none are in successful operation at present several give promise of future production. On one property a short distance from Nome a mill has recently been erected and some ore tested. On another property a lode carrying nearly 50 per cent of antimony sulphide and notable amounts of gold and silver has been opened and awaits the capital necessary for its operation. Lodes carrying other metallic sulphides are known. Deposits of copper, lead, and graphite have been prospected, but have not contributed any notable production. Bismuth, iron, and arsenic sulphides are not known to occur in workable quantities in the quartz lodes, but may prove valuable for the gold they contain. Deposits of iron oxide have been reported near tidewater a short distance from Nome, but have never been developed.

GOLD.

On account of the great amount of placer gold which this region has yielded, the principal interest in lode mining centers in the discovery of gold-bearing lodes. The opening of gold-bearing fissure veins and other workable deposits in this vicinity has helped to remove the prejudice against lode mining and to stimulate interest in prospecting. The greatest activity in lode prospecting in the vicinity of Nome has been on Anvil and King mountains and on the divide between Anvil and Glacier creeks. (See [illegible]13.) Recently a number of claims have been staked and the nece[illegible] assessment work done, but what is generally recognized as development work is rarely carried on, and, as a rule, surface cuts are the only workings.

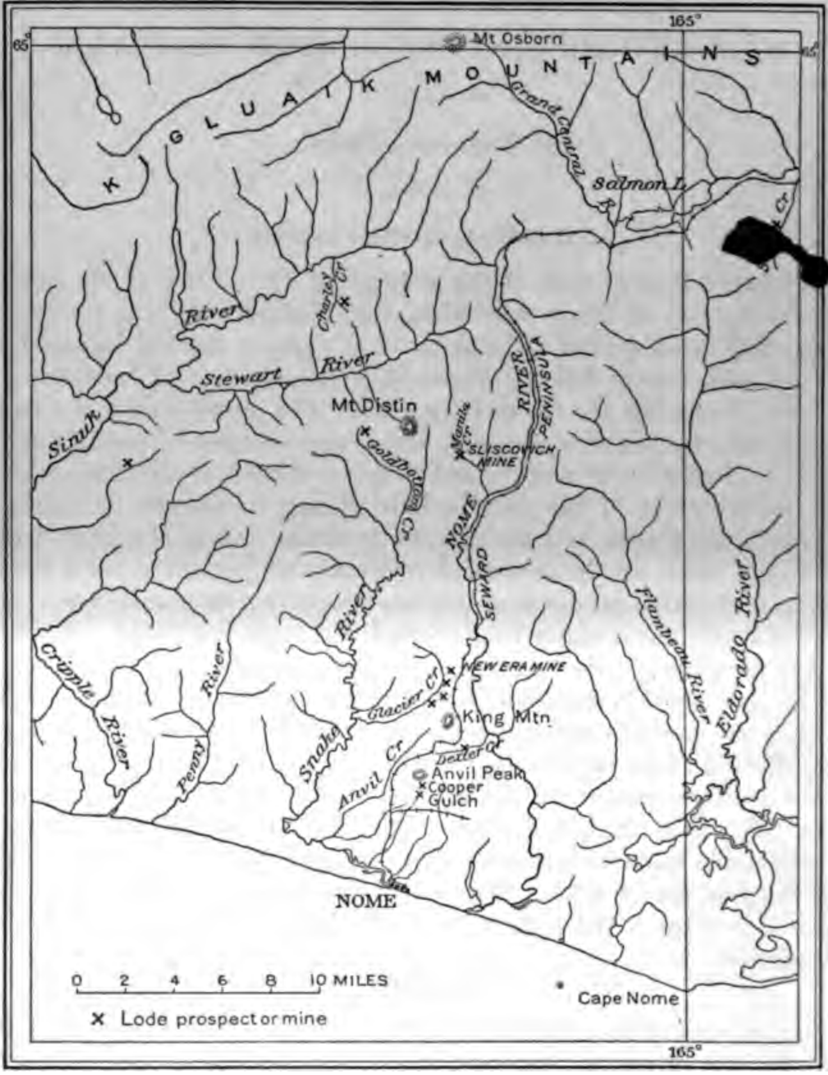


FIGURE 13.—Sketch map showing location of auriferous lodes near Nome.

GEOLOGY.

The prevailing rocks in the vicinity of Nome belong to what has been called the Nome group,[1] and consist of schists containing limestone beds and locally intruded by greenstone and granite. There

---

[1] Moffit, F. H., Geology of the Nome and Grand Central quadrangles, Alaska: U. S. Geol. Survey Bull. 533, pp. 20-28, 1913.

are also extensive deposits of gravel, some of which are marine and some fluviatile. The schists are broadly classified as chloritic, feldspathic, and siliceous graphitic schists. All the lode deposits are found in the Nome group and the included intrusive rocks.

TYPES OF GOLD LODES.

The gold lodes of the Nome region are divided into two general classes—vein deposits and disseminated deposits.[1] The veins include those deposits in which mineralization occurred along more or less well defined structural planes. They contain a considerable amount of quartz or calcite gangue. The disseminated deposits occur in fracture zones, mineralized by gold-bearing solutions that penetrated along minute openings. Such deposits are poorly defined and grade insensibly into the surrounding rocks. These two modes of occurrence are not sharply differentiated, but show gradations from one to the other. On the basis of vein material the vein deposits are divided into quartz veins, calcite veins, and veins composed of quartz, albite, and chlorite. The quartz veins are the only ones thought to be commercially important, although calcite veins are known to carry free gold. The auriferous quartz veins have further been separated into two classes, one in which the gold is associated with the sulphides of iron, arsenic, and antimony or other minerals, and one in which the gold has no mineral association except with the quartz.

In the sulphide-bearing lodes, whether fissure veins or disseminated fracture zones, the gold either occurs free in the sulphide or inclosing quartz or is present in a state of chemical combination. A division made on this basis is the most important classification from economic considerations, as the deposits of the two kinds require entirely different plants for the treatment of the ore. Failure on the part of operators to determine the character of the ore in depth has caused considerable loss in the erection of machinery not suitable for treating the ore.

The gold-bearing lodes of Seward Peninsula have been characterized[2] as a type of Alaskan deposits peculiar to this region, as it has never been proved that they bear a genetic relation to intrusive rocks, like most of the other gold-lode deposits of Alaska. This is true of the greater number of the lodes, but a type which appears to be somewhat different from those previously described and apparently directly connected with intrusive rocks is found in a mineralized dike (p. 405). This lode, which was recently opened, may not prove to be of economic importance, but is interesting as a new type of lode in this vicinity.

---

[1] Moffit, F. H., op. cit., p. 128.

[2] Brooks, A. H., Geologic features of Alaskan metalliferous lodes: U. S. Geol. Survey Bull. 480, p. 70, 1911.

MINES AND PROSPECTS.

NEW ERA MINE.

The property of the New Era Mining Co. is about 6 miles north of Nome. (See fig. 13, p. 398.) The claims are located on Snow Gulch, a tributary of Glacier Creek, and on Kanoma Gulch, a small branch of Snow Gulch. The ore bodies are stringer lodes and disseminated deposits in schist and occur near a limestone contact.

The principal underground development consists of a tunnel 315 feet long, driven to crosscut the lode, which is said to strike about northeast and dip 40° NW. At the time the tunnel was visited a cave-in rendered it inaccessible, so only surface workings could be examined. The face of the tunnel was said to be 10 feet in ore, but the entire width of the lode had not been determined. The lode, as judged by specimens from the dump, is composed of stringers of quartz with much included schist, both quartz and schist containing considerable pyrite and arsenopyrite. The arsenopyrite occurs as small irregular bunches and as isolated crystals in both vein matter and schist and appears to be contemporaneous with the quartz. Some of the pyrite may perhaps have the same relation, but most of it is of later origin than the arsenopyrite and fills fractures which penetrate that mineral. A small amount of albite occurs with the quartz. Small bunches of calcite were seen in pyritized schist, but their relation to the quartz was not determined.

No visible gold could be detected in any of the samples taken from this tunnel, nor can free gold be obtained on crushing the ore. The gold is contained in the sulphides and extends into the wall rock for a considerable distance. The quartz stringers are frozen to the schist and do not easily separate from it, but this is not a serious obstacle, for the included schist is mineralized. As the wall rock also contains gold, the width of the minable rock must be determined not by the walls of the vein matter but by the distance to which the mineralization has penetrated the walls. Assays on ore taken from the tunnel show high values, but inasmuch as many of these assays were made from very small samples, they carry little weight in determining the average value of the lode.

On the ridge between Nakoma and New Year gulches, at an elevation of 600 feet, an opening has been made on a lode which strikes N. 60° E. and dips 75° NW. The lode is about 6 feet wide and is composed of schist cut by nonpersistent lenses of quartz with few sulphides. The gold is concentrated along the footwall of the lode, where particles of visible gold occur in gash veins. Assays made on about 5 inches of the footwall are said to have shown high values, but the conditions under which this material was selected are not known.

A short distance below this opening is a mineralized zone of schist 100 feet wide. It occurs at a limestone contact and appears to be a deposit of the disseminated type. A small opening had been made but did not penetrate the oxidized surface zone, so the unaltered part of the ore body was not visible. The surface zone is soft, decomposed chloritic schist of dark-green color minutely seamed along fractures with tiny threads of iron oxide, evidently derived from the oxidation of the pyrite which occurs as impregnations in the schist. Quartz is not visible except as lenses in the schist. The managers report that careful sampling across the surface of this lode indicated the presence of gold in commercial quantities, but a test mill run of 150 tons of the ore showed that only a portion of the gold contained is free-milling, for less than half the amount indicated by the assay was recovered on the plates. The surface portions of the lode may have a gold content much greater than the lower portions, for the gold contained in the surface zone may be the residual concentration from a considerable vertical section of the vein, now removed by erosion. Considerable prospecting will be necessary to determine the gold content at depth and the size and extent of the ore body, inasmuch as the lode of this character is not as regular as a fissure vein.

The custom stamp mill at Nome was taken over by the New Era Mining Co. upon its reorganization last year and placed on the property at Snow Gulch. This was a great convenience in making test runs, but it was soon evident that the mill was poorly equipped for treating the ore, for much of the gold was not recoverable by the simple process of crushing and amalgamation employed in this mill. Plans for testing the claims with a diamond drill have been made.

About half a mile southwest of the New Era tunnel, at an elevation of 450 feet above sea level, the Golden Eagle claim has been staked on a lode which appears to be the same one cut by the New Era workings. The lode is being prospected by a drift tunnel, which at the time of visit was about 50 feet under cover. The vein where exposed on the surface was only about 6 inches thick, but it grows wider with depth and at the face of the tunnel has a thickness of over 6 feet. It is composed of dull opaque quartz and carries no sulphides. The operators state that samples representative of the ore of the entire vein showed commercial values.

ANVIL CREEK.

A little prospecting has recently been done on Anvil Creek, but at the time of visit no work was in progress. Near the mouth of Quartz Gulch a lode with a general northeast strike and steep northwest dip has been opened in several places by shallow surface cuts. The lode is a crushed zone in schist filled with reticulating veins composed of quartz and a carbonate which appears to be dolomite. The exact composition of this mineral was not determined, but chemical tests show it to be a carbonate of calcium and magnesium with only a trace of iron and to be near the composition of dolomite.

The metallic content of the lode consists of pyrite and arsenopyrite, which appear to have been introduced at different times. The arsenopyrite for the most part occurs as large crystals and irregular masses in both quartz and dolomite and is evidently contemporaneous with the primary vein formation. The pyrite is of later origin and occurs as reticulating veins cutting the quartz-carbonate vein and including grains of the arsenopyrite.

A claim on the ridge between Anvil Creek and Snake River, near the north end of the knoll west of Banner station, has been prospected recently. An irregular body of quartz was opened by a shallow surface cut, but not enough work was done to show the relations. No well-defined vein is in view. The lode consists of dull-white quartz with no sulphides or visible gold. Stringers of quartz penetrate the schist, and blocks of schist are included in the quartz mass.

GOLDBOTTOM CREEK.

Considerable development work is reported to have been done on the Connolly & Jensen quartz mine, on Goldbottom Creek. This property is equipped with a small stamp mill run by water power and was necessarily idle during the drought of the summer of 1913. It is stated, however, that a quantity of ore is ready to be milled whenever water is available.

COOPER GULCH.

Near the head of Cooper Gulch, about half a mile east of Anvil Peak, a little work has been done on a calcite vein. A number of openings have been made on the lode, but the only accessible one was a short open cut which showed a reticulating vein of calcite. The strike of the vein is in general N. 30° E., but it is very irregular in direction and dip. In places it stands vertically, but in others it flattens out into lenses that lie nearly horizontal. The country rock is schistose limestone.

A short distance to the east, near the limestone contact in the schist, another claim is being prospected by a short tunnel that exposes the lode for a few feet. The lode is defined by two polished vertical walls about 4 feet apart, which inclose ledge matter and brecciated schist, all more or less mineralized. The interior and borders of the lode are composed of bodies of ferruginous calcite, between which are masses of crushed schist that has been partly replaced by calcite. The calcite of the veins and the replaced areas has been altered in large part to limonite, which gives a rusty appearance to the entire lode. Some shattering evidently followed the formation of the lode, as calcite veinlets fill fractures that penetrate vein and wall rock. No sulphides or gold were seen on specimens of the rock.

DEXTER CREEK.

On Dexter Creek about 300 feet above the mouth of Grouse Gulch a prospect tunnel has been driven for a distance of 400 feet. The wall rock exposed at the portal, the only part of the workings accessible at the time of visit, is decomposed mica schist, and the entire tunnel is said to be in rock of similar character. No evidence of mineralization is apparent, although the inclosing rock is reported to contain gold.

Assessment work on a number of other claims in this vicinity is reported, but little work has been done in developing them.

SLISCOVICH MINE.

Several quartz veins containing antimony have been opened on Seward Peninsula, but only one of them, the Sliscovich mine, has been developed to a producing basis. This property, situated near the head of Manila Creek, at an elevation of 1,100 feet (fig. 13, p. 398), was staked in 1905, and a little work has been done on it each year since. The vein, which strikes N. 60° E. and dips 45° NW., was traced on the surface for over half a mile, nearly across the basin of Manila Creek. Besides a number of prospect pits two openings have been made to develop the lode. A short distance below the point of discovery a 50-foot adit was driven to crosscut the lode, but no further work was done at this place. The main opening is at an elevation 100 feet lower. There an adit was driven 315 feet to the lode, which was opened by an inclined shaft for 100 feet.

The lode is composed essentially of dull, opaque quartz and stibnite, the sulphide of antimony, in approximately equal amounts, although slight variations in the proportions of the two minerals appear from place to place. Near the surface the antimony predominates, and in places nearly pure stibnite occurs in small bunches. A number of assays and analyses have been made on samples of the ore, all of which show rather constant antimony, gold, and silver. An analysis made on a small shipment of ore said by the owners to have been obtained by accurate sampling of the vein was submitted for chemical determination and showed the following:

Gold and silver not published.	
Antimony (Sb)	35.05
Sulphur (S)	13.79
Silica (SiO_2)	48.80
Molybdenum (Mo)	None.
Qualitative arsenic (As)	None.
Wet lead	Trace.
	97.64

Lime and magnesia present but not determined quantitatively.

An analysis by the Tacoma Smelting Co., of Tacoma, Wash., showed:

Gold and silver not published.

Antimony	36.40
Silica	49.00
Iron	5.10
	90.50

Although locally referred to as "the antimony mine," the property is being exploited solely for its content of gold and silver. The antimony appears to be of later origin than the quartz. Brecciated vein quartz has been healed by masses of stibnite that have inclosed quartz fragments and penetrated them as tiny veinlets of the sulphide.

The gold has two modes of occurrence. A part of it is free and may be seen readily in picked hand specimens (Pl. XVII). An examination of polished sections shows the greater part of the visible gold to be associated with the stibnite and to occur along the borders of the stibnite areas or in the connected cracks and veinlets which penetrate the quartz. It was probably introduced with the antimony. A small amount of the gold, however, has no apparent connection with the stibnite and may have been introduced with the quartz prior to the sulphide mineralization. The free gold is not evenly distributed throughout the vein but occurs in bunches and appears to be more plentiful in the surface portion of the vein. The greater part of the gold contained is invisible, occurring in a state of chemical combination with the stibnite. It may thus be seen that the lode owes its economic value to the sulphide mineralization, for most of the gold in both modes of occurrence was introduced through this agency. Locally the lode widens and narrows, varying in thickness from about 20 inches to 3 feet and appearing to widen and to become a little steeper with depth.

The country rock is dark-green chloritic schist composed mainly of quartz, chlorite, and colorless mica, in large part muscovite, with accessory amounts of calcite, epidote, hematite, and zircon. Bordering a seam of gouge that defines the footwall of the lode, about 15 inches of the wall rock has been altered to a mass of quartz and sericite with considerable white pyrite in small aggregate. The altered wall rock also contains small seams of gouge. The country rock along the hanging wall also has been silicified, but to a lesser extent.

Ore has not been mined regularly, but several small shipments have been made primarily for mill tests to determine the value of the ore.

CHARLEY CREEK.

Bismuth-bearing quartz veins occur on Charley Creek, a small stream which enters Sinuk River about 25 miles north of Nome. Moffit[1] visited this locality in 1906 and noted the occurrence of two

---

[1] Moffit, F. H., op. cit., p. 133.

ORE FROM SLISCOVICH MINE, NOME DISTRICT.

A, Natural size; *B*, Same specimen enlarged 2 diameters.

parallel quartz veins that were found to carry bismuth. These veins are about 8 and 12 inches thick and are separated by 16 to 18 inches of schist. They occur in strike joints dipping 50°-60°. At that time they were traceable on the surface for only a short distance because of the covering of slide rock. It is reported that recent prospecting on Charley Creek has uncovered a 4-foot quartz vein that carries 15 per cent of bismuth and a fair gold content. This locality was not visited in 1913, but a sample of the ore was obtained. It is composed of dull white and gray quartz, with small masses of intergrown native bismuth and bismuthinite (bismuth trisulphide).

SLATE CREEK.

A prospect is being opened on Slate Creek, a small stream which flows into Kruzgamepa River from the south 4 miles east of Salmon Lake. The lode is a mineralized dike cutting greenstone. The rock is badly weathered, so that its original character is in doubt, but it appears to have been a fine-grained quartz-feldspar rock in which all the feldspar is now replaced by sericite and kaolin. The dike has been fractured and filled with ferruginous calcite that has partly replaced the included fragments and the walls. A later fracturing of the lode was healed by irregular veinlets composed of quartz and calcite deposited simultaneously. No assays of this lode were made, but small amounts of gold were obtained by crushing and panning the rock. The ledge, which is about 3 feet wide, strikes east and dips 70° N.

A short distance south of the open cut mentioned is an outcrop of rock which appears to be another dike about 10 feet thick and parallel to the one described. It is an even-textured rock of gray color and very fine grain and, like the other dike, was probably a quartz-feldspar intrusive. Quartz, the only original mineral now found in it, occurs with a finely granular mass of epidote. Traversing the rock in many directions are irregular veinlets composed mainly of a green silvery micaceous mineral which proves to be chlorite. With it are associated a number of other vein minerals—quartz, albite, calcite, epidote, and a colorless amphibole which is probably tremolite. This dike is not thought by the prospectors to be of economic value, and work has therefore been confined to the other lode.

The country rock is fine-grained greenstone. It is evident that this was originally a basic igneous rock, but it has been entirely recrystallized. Green hornblende is the most conspicuous mineral, but considerable amounts of chlorite and epidote are present. Garnet and pyrite are abundant and may be readily seen in the hand specimen. Albite fills the interspaces and includes rutile and titanite and fragments of other minerals.

The claims covering this property were located on Slate Creek half a mile above the mouth of Rock Creek in the spring of 1913. At the time of visit the only development work done was a small surface cut, but plans were being made to open the lode by an inclined shaft.

IRON.

Deposits of iron ore in the Nome region have been prospected and a number of locations have been recorded. The property, composed of four groups of claims, is located on Sinuk River and some of its tributaries, about 18 miles from the coast and 20 miles northeast of Nome in a direct line, although the route traveled to reach it is about 30 miles long. This locality was not visited, and information regarding it was furnished by the owners of the claims. The bedrock is described as consisting of chloritic, micaceous, and talcose schists, cut by sills and dikes of greenstone and overlain by limestone, inclosing the bodies of iron ore, which covers an area 25 miles long and 10 miles wide. Development work has been done only on the Monarch group, situated between Sinuk River and Washington Creek. One shaft and 30 open trenches on this group of claims have disclosed a large ore body. Specimens of ore in the possession of the owners of this property were examined. The highest-grade ore is composed essentially of limonite, which is rather massive except along the numerous open spaces, where botryoidal and mammillary forms exhibiting fibrous texture are well developed. A little hematite is also present as narrow layers separating the massive from the fibrous limonite. Ore of poorer grade contains more or less limestone.

The following analyses furnished by the owners of the claims were made by the Western Steel Corporation, of Seattle, on samples said to be representative of the ore in various cuts:

Iron.	Silica.	Phosphorus.	Manganese.
58.76	2.14	0.026	0.44
53.92	8.65	.022	.74
59.86	3.85	.010	.38
57.55	4.82	.015	.76
37.19	.90	.004	.90
15.29	2.70	.017	11.22

The following report was made by the Pacific Coast Testing Laboratory on samples submitted to it by the owners of the property:

Iron.	Silica.	Phosphorus.	Manganese.	Lime.
53.88	7.07	0.047	0.83	....
45.34	4.15	.049	.89	....
34.76	1.00	.038	.92	23.00

Some gold is also reported, but no assay returns are available for publication.

No work other than that necessary to hold the ground is being done on this or the adjoining groups of claims, although for years there have been indefinite plans either to open the property and ship the high-grade ore or to erect a plant on the ground for its treatment. Natural resources which might be utilized for the production of power are available near by. A hot spring 2 miles below the location of the claims is said to maintain a uniform flow during summer and winter and could possibly be used to generate electric power. Another possible resource is coal. Coal-bearing rocks outcrop on Coal Creek, a tributary of Sinuk River, a short distance below the iron prospects. It is reported that a tunnel driven to prospect the coal cut 17 thin seams ranging in thickness from 3 to 16 inches. The coal is said to be of bituminous grade and of fair quality, but the extent of the coal-bearing rocks is not known.[1]

TIN.

Ever since placer tin was first produced on Seward Peninsula search for its bedrock source has been continued and a number of tin-bearing lodes have been located, but no regular production has been maintained. In 1906 the Bartels Tin Mining Co. milled 10 tons of concentrates, the first and until this year the only production recorded from tin lodes in Alaska.

The Lost River tin-bearing lode prospects are located 6 miles from the coast, on Cassiterite Creek, a tributary of Lost River, in the extreme eastern part of Seward Peninsula. This property has recently been taken over by the Jamme Syndicate and actively developed. A small concentrating plant erected in the spring of 1913 was operated for about two months to test operating conditions fully and produced 5,000 pounds of concentrates containing over 60 per cent of metallic tin and 11 per cent of tungsten. The ore bodies of this locality are described as mineralized dikes of quartz porphyry which cut the Port Clarence limestone and are intimately connected with granitic intrusions.[2] Plans for future development include the installation of a larger plant on the property, as well as a smelter at Seattle.

On Ear Mountain during the summer of 1913 a party of men were prospecting a tin lode and found tin in sufficient quantity to encourage further winter development. The ore is reported to lie in a shear zone in the granite.

Tin lodes are known also at Brooks Mountain, at Cape Mountain, and on Buck Creek, but little work has been done at any of these places recently.

---

[1] Collier, A. J., The gold placers of parts of Seward Peninsula, Alaska: U. S. Geol. Survey Bull. 328, p. 84, 1908.

[2] Knopf, Adolph, Geology of the Seward Peninsula tin deposits, Alaska: U. S. Geol. Survey Bull. 358, p. 40, 1908.

INDEX.

RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All these publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained free of charge (except certain maps) on application.
2. A certain number are delivered to Senators and Representatives in Congress for distribution.
3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost. The publications marked with an asterisk (*) in this list are out of stock at the Survey but can be purchased from the Superintendent of Documents at the prices stated.
4. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

GENERAL.

REPORTS.

*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper 45, 1906, 327 pp. $1.

Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin 259, 1905, pp. 18–31.

The mining industry in 1905, by A. H. Brooks. In Bulletin 284, 1906, pp. 4–9.

The mining industry in 1906, by A. H. Brooks. In Bulletin 314, 1907, pp. 19–39.

*The mining industry in 1907, by A. H. Brooks. In Bulletin 345, 1908, pp. 30–53. 45 cents.

*The mining industry in 1908, by A. H. Brooks. In Bulletin 379, 1909, pp. 21–62. 50 cents.

The mining industry in 1909, by A. H. Brooks. In Bulletin 442, 1910, pp. 20–46.

The mining industry in 1910, by A. H. Brooks. In Bulletin 480, 1911, pp. 21–42.

*The mining industry in 1911, by A. H. Brooks. In Bulletin 520, 1912, pp. 19–44. 50 cents.

The mining industry in 1912, by A. H. Brooks. In Bulletin 542, 1913, pp. 18–51.

The Alaskan mining industry in 1913, by A. H. Brooks. In Bulletin 592, 1914, pp. 45–74.

Railway routes, by A. H. Brooks. In Bulletin 284, 1906, pp. 10–17.

*Railway routes from the Pacific seaboard to Fairbanks, Alaska, by A. H. Brooks. In Bulletin 520, 1912, pp. 45–88. 50 cents.

Geologic features of Alaskan metalliferous lodes, by A. H. Brooks. In Bulletin 480, 1911, pp. 43–93.

The mineral deposits of Alaska, by A. H. Brooks. In Bulletin 592, 1914, pp. 18–44.

*Tin resources of Alaska, by F. L. Hess. In Bulletin 520, 1912, pp. 89–92. 50 cents.

Administrative report, by A. H. Brooks. In Bulletin 259, 1905, pp. 13–17.

Administrative report, by A. H. Brooks. In Bulletin 284, 1906, pp. 1–3.

Administrative report, by A. H. Brooks. In Bulletin 314, 1907, pp. 11–18.

*Administrative report, by A. H. Brooks. In Bulletin 345, 1908, pp. 5–17. 45 cents.

*Administrative report, by A. H. Brooks. In Bulletin 379, 1909, pp. 5–20. 50 cents.

Administrative report, by A. H. Brooks. In Bulletin 442, 1910, pp. 5–19.

Administrative report, by A. H. Brooks. In Bulletin 480, 1911, pp. 5–14.

*Administrative report, by A. H. Brooks. In Bulletin 520, 1912, pp. 7–18. 50 cents.

Administrative report, by A. H. Brooks. In Bulletin 542, 1913, pp. 7–17.

Administrative report, by A. H. Brooks. In Bulletin 592, 1914, pp. 7–17.

Report on progress of surveys of public lands in Alaska during 1910, by A. H. Brooks. In Bulletin 480, 1911, pp. 15–20.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.

Alaska coal and its utilization, by A. H. Brooks. Bulletin 442J, reprinted 1914.

*The possible use of peat fuel in Alaska, by C. A. Davis. In Bulletin 379, 1909, pp. 63–66. 50 cents.

The preparation and use of peat as a fuel, by C. A. Davis. In Bulletin 442, 1910, pp. 101–132.

*The distribution of mineral resources in Alaska, by A. H. Brooks. In Bulletin 345, pp. 18–29. 45 cents.

Mineral resources of Alaska, by A. H. Brooks. In Bulletin 394, 1909, pp. 172–207.

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 362 pp. (Abstract in Bulletin 259, 1905, pp. 32–46.)

*Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin 345, 1908, pp. 54–77. 45 cents.

*Geographic dictionary of Alaska, by Marcus Baker; second edition prepared by James McCormick. Bulletin 299, 1906, 690 pp. 50 cents.

MAPS.

*Map of Alaska showing contours; scale, 1 : 2,500,000; preliminary edition; by R. U. Goode. In *Professional Paper 45. $1. Not issued separately.

*Map of Alaska showing distribution of mineral resources; scale, 1: 5,000,000; by A. A. Brooks. In *Bulletin 345. 45 cents. Not issued separately.

Map of Alaska; scale, 1:5,000,000; by Alfred H. Brooks. 20 cents.

Map of Alaska showing distribution of metalliferous deposits; scale, 1:5,000,000; by A. H. Brooks. In Bulletin 480. Not issued separately.

Map of Alaska showing distribution of mineral deposits; scale, 1:5,000,000; by A. H. Brooks. 20 cents. Also included in *Bulletin 520. 50 cents. (New edition included in Bulletin 592.)

SOUTHEASTERN ALASKA.

REPORTS.

*Preliminary report on the Ketchikan mining district, Alaska, with an introductory sketch of the geology of southeastern Alaska, by Alfred H. Brooks. Professional Paper 1, 1902, 120 pp. 25 cents.

*The Porcupine placer district, Alaska, by C. W. Wright. Bulletin 236, 1904, 35 pp. 15 cents.

The Treadwell ore deposits, by A. C. Spencer. In Bulletin 259, 1905, pp. 69–87.

Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 259, 1905, pp. 47–68.

*The Juneau gold belt, Alaska, by A. C. Spencer, pp. 1–137, and A reconnaissance of Admiralty Island, Alaska, by C. W. Wright, pp. 138–154. Bulletin 287, 1906, 161 pp. 75 cents.

Lode mining in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 284, 1906, pp. 30-53.

Nonmetallic deposits of southeastern Alaska, by C. W. Wright. In Bulletin 284, 1906, pp. 54-60.

The Yakutat Bay region, by R. S. Tarr. In Bulletin 284, 1906, pp. 61-64.

Lode mining in southeastern Alaska, by C. W. Wright. In Bulletin 314, 1907, pp. 47-72.

Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. In Bulletin 314, 1907, pp. 73-81.

Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. In Bulletin 314, 1907, pp. 82-88.

*Lode mining in southeastern Alaska, 1907, by C. W. Wright. In Bulletin 345, 1908, pp. 78-97. 45 cents.

*The building stones and materials of southeastern Alaska, by C. W. Wright. In Bulletin 345, 1908, pp. 116-126. 45 cents.

*Copper deposits on Kasaan Peninsula, Prince of Wales Island, by C. W. Wright and Sidney Paige. In Bulletin 345, 1908, pp. 98-115. 45 cents.

*The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright. Bulletin 347, 1908, 210 pp. 60 cents.

*The Yakutat Bay region, Alaska: Physiography and glacial geology, by R. S. Tarr; Areal geology, by R. S. Tarr and B. S. Butler. Professional Paper 64, 1909, 186 pp. 50 cents.

*Mining in southeastern Alaska, by C. W. Wright. In Bulletin 379, 1909, pp. 67-86. 50 cents.

Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 442, 1910, pp. 133-143.

Occurrence of iron ore near Haines, by Adolph Knopf. In Bulletin 442, 1910, pp. 144-146.

Report of water-power reconnaissance in southeastern Alaska, by J. C. Hoyt. In Bulletin 442, 1910, pp. 147-157.

Geology of the Berners Bay region, Alaska, by Adolph Knopf. Bulletin 446, 1911, 58 pp.

Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 480, 1911, pp. 94-102.

The Eagle River region, by Adolph Knopf. In Bulletin 480, 1911, pp. 103-111.

The Eagle River region, southeastern Alaska, by Adolph Knopf. Bulletin 502, 1912, 61 pp.

The Sitka mining district, Alaska, by Adolph Knopf. Bulletin 504, 1912, 32 pp.

The earthquakes at Yakutat Bay, Alaska, in September, 1899, by R. S. Tarr and Lawrence Martin, with a preface by G. K. Gilbert. Professional Paper 69, 1912, 135 pp.

Marble resources of Ketchikan and Wrangell districts, by E. F. Burchard. In Bulletin 542, 1913, pp. 52-77.

Marble resources of the Juneau, Skagway, and Sitka districts, by E. F. Burchard. In Bulletin 592, 1914, pp. 95-107.

A barite deposit near Wrangell, by E. F. Burchard. In Bulletin 592, 1914, pp. 109-117.

Lode mining in the Ketchikan district, by P. S. Smith. In Bulletin 592, 1914, pp. 75-94.

In press.

The geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska, by C. W. Wright. Professional Paper 87.

TOPOGRAPHIC MAPS.

*Juneau gold belt, Alaska; scale, 1:250,000; compiled. In *Bulletin 287. 75 cents. Not issued separately.

Juneau special (No. 581A); scale, 1:62,500; by W. J. Peters. 10 cents each, or $3 for 50.

Berners Bay special (No. 581B); scale, 1:62,500; by R. B. Oliver. 10 cents each, or $3 for 50.

Kasaan Peninsula, Prince of Wales Island (No. 540A); scale, 1:62,500; by D. C. Witherspoon, R. H. Sargent, and J. W. Bagley. 10 cents each, or $3 for 50.

Copper Mountain and vicinity, Prince of Wales Island (No. 540B); scale, 1:62,500; by R. H. Sargent. 10 cents each, or $3 for 50.

Eagle River region (No. 581C); scale, 1:62,500; by J. W. Bagley, C. E. Giffin, and R. E. Johnson. In Bulletin 502. Not issued separately.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

REPORTS.

The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall. Professional Paper 15, 1903, 71 pp.

Bering River coal field, by G. C. Martin. In Bulletin 259, 1905, pp. 140–150.

Cape Yaktag placers, by G. C. Martin. In Bulletin 259, 1905, pp. 88–89.

Notes on the petroleum fields of Alaska, by G. C. Martin. (Abstract from Bulletin 250.) In Bulletin 259, 1905, pp. 128–139.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.

Geology of the central Copper River region, Alaska, by W. C. Mendenhall. Professional Paper 41, 1905, 133 pp.

***Mineral resources of Kenai Peninsula: Gold fields of the Turnagain Arm region, by F. H. Moffit, pp. 1–52; Coal fields of the Kachemak Bay region, by R. W. Stone, pp. 53–73.** Bulletin 277, 1906, 88 pp. 25 cents.

Geology and mineral resources of Controller Bay region, Alaska, by G. C. Martin. Bulletin 335, 1908, 141 pp.

*Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin 345, 1908, pp. 176–178. 45 cents.

*Mineral resources of the Kotsina and Chitina valleys, Copper River region, by F. H. Moffit and A. G. Maddren. In Bulletin 345, 1908, pp. 127–175. 45 cents.

Mineral resources of the Kotsina-Chitina region, by F. H. Moffit and A. G. Maddren. Bulletin 374, 1909, 103 pp.

*Copper mining and prospecting on Prince William Sound, by U. S. Grant and D. F. Higgins, jr. In Bulletin 379, 1909, pp. 87–96. 50 cents.

*Gold on Prince William Sound, by U. S. Grant. In Bulletin 379, 1909, p. 97. 50 cents.

*Mining in the Kotsina-Chitina, Chistochina, and Valdez Creek regions, by F. H. Moffit. In Bulletin 379, 1909, pp. 153–160. 50 cents.

Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf; with a section on the Quaternary, by S. R. Capps. Bulletin 417, 1910, 64 pp.

Mining in the Chitina district, by F. H. Moffit. In Bulletin 442, 1910, pp. 158–163.

Mining and prospecting on Prince William Sound in 1909, by U. S. Grant. In Bulletin 442, 1910, pp. 164–165.

Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 443, 1910, 89 pp.

Geology and mineral resources of the Nizina district, Alaska, by F. H. Moffit and S. R. Capps. Bulletin 448, 1911, 111 pp.

Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts, by F. H. Moffit. Bulletin 498, 1912, 82 pp.

*The Taral and Bremner districts, by F. H. Moffit. In Bulletin 520, 1912, pp. 93–104. 50 cents.

*The Chitina district, by F. H. Moffit. In Bulletin 520, 1912, pp. 105–107. 50 cents.

*Gold deposits near Valdez, by A. H. Brooks. In Bulletin 520, 1912, pp. 108–130. 50 cents.

Coastal glaciers of Prince William Sound and Kenai Peninsula, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 526, 1913, 75 pp.

The McKinley Lake district, by Theodore Chapin. In Bulletin 542, 1913, pp. 78–80.

Mining in Chitina Valley, by F. H. Moffit. In Bulletin 542, 1913, pp. 81–85.

Mineral deposits of the Ellamar district, by S. R. Capps and B. L. Johnson. In Bulletin 542, 1913, pp. 86–124.

The mineral deposits of the Yakataga region, by A. G. Maddren. In Bulletin 592, 1914, pp. —.

Preliminary report on water power of south-central Alaska, by C. E. Ellsworth and Royal W. Davenport. In Bulletin 592, 1914, pp. —.

The Port Wells gold-lode district, by B. L. Johnson. In Bulletin 592, 1914, pp. —.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 592, 1914, pp. —.

In press.

Geology of the Hanagita-Bremner region, by F. H. Moffit. Bulletin 576.

Contributions to the geology and mineral resources of Kenai Peninsula, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587.

In preparation.

The Ellamar district, by S. R. Capps and B. L. Johnson. Bulletin ——.

A water-power reconnaissance in south-central Alaska, by C. E. Ellsworth and Royal W. Davenport.

TOPOGRAPHIC MAPS.

Central Copper River region; reconnaissance map; scale, 1:250,000; by T. G. Gerdine. In Professional Paper 41. Not issued separately.

Headwater regions of Copper, Nabesna, and Chisana rivers; reconnaissance map; scale, 1:250,000; by D. C. Witherspoon, T. G. Gerdine, and W. J. Peters. In Professional Paper 41. Not issued separately.

Alaska coast region from Yakutat Bay to Prince William Sound; scale, 1:1,200,000; compiled by G. C. Martin. In Bulletin 335. Not issued separately.

Controller Bay region; scale, 1:62,500; by E. G. Hamilton and W. R. Hill. 35 cents. No wholesale rate.

Chitina quadrangle; reconnaissance map; scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. In Bulletin 374. Not issued separately.

Nizina district; scale, 1:62,500; by D. C. Witherspoon and R. M. La Follette. In Bulletin 448. Not issued separately.

Headwater region of Gulkana and Susitna rivers; scale, 1:250,000; by D. C. Witherspoon, J. W. Bagley, and C. E. Giffin. In Bulletin 498. Not issued separately.

Prince William Sound; scale, 1:500,000; compiled. In Bulletin 526. Not issued separately.

In preparation.

Ellamar district; scale, 1:62,500; by R. H. Sargent and C. E. Giffin.

Port Valdez district; scale, 1:62,500; by C. E. Giffin.

COOK INLET AND SUSITNA REGION.

REPORTS.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.

A reconnaissance of the Matanuska coal field, Alaska, in 1905, by G. C. Martin. Bulletin 289, 1906, 36 pp.

Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska, by Sidney Paige and Adolph Knopf. Bulletin 327, 1907, 71 pp.

*Notes on geology and mineral prospects in the vicinity of Seward, Kenai Peninsula, by U. S. Grant. In Bulletin 379, 1909, pp. 98-107. 50 cents.

Preliminary report on the mineral resources of the southern part of Kenai Peninsula, by U. S. Grant and D. F. Higgins. In Bulletin 442, 1910, pp. 166-178.

Gold placers of the Mulchatna, by F. J. Katz. In Bulletin 442, 1910, pp. 201-202.

The Mount McKinley region, Alaska, by A. H. Brooks, with descriptions of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle. Professional Paper 70, 1911, 234 pp.

A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp.

Geology and coal fields of the lower Matanuska Valley, Alaska, by G. C. Martin and F. J. Katz. Bulletin 500, 1912, 98 pp.

*Gold deposits of the Seward-Sunrise region, Kenai Peninsula, by B. L. Johnson. In Bulletin 520, 1912, pp. 131-173. 50 cents.

The Yentna district, Alaska, by S. R. Capps. Bulletin 534, 1913, 75 pp.

A reconnaissance of the Willow Creek gold region, by F. J. Katz. In Bulletin 480, 1911, p. 152.

Gold lodes and placers of the Willow Creek district, by S. R. Capps. In Bulletin 592, 1914, pp. —.

Mineral resources of the upper Matanuska and Nelchina valleys, by G. C. Martin and J. B. Mertie, jr. In Bulletin 592, 1914, pp. —.

Preliminary report on the Broad Pass region, by F. H. Moffit. In Bulletin 592, 1914, pp. —.

Mining in the Valdez Creek placer district, by F. H. Moffit. In Bulletin 592, 1914, pp. —.

In press.

Contributions to the geology and mineral resources of Kenai Peninsula, Alaska, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587.

In preparation.

The Willow Creek district, by S. R. Capps.

The Broad Pass region, by F. H. Moffit and J. E. Pogue.

TOPOGRAPHIC MAPS.

Kenai Peninsula, southern portion; scale, 1: 500,000; compiled. In Bulletin 526. Not issued separately.

Matanuska and Talkeetna region, reconnaissance map; scale, 1: 250,000; by T. G. Gerdine and R. H. Sargent. In Bulletin 327. Not issued separately.

Lower Matanuska Valley; scale, 1: 62,500; by R. H. Sargent. In Bulletin 500. Not issued separately.

Yentna district, reconnaissance map; scale, 1: 250,000; by R. W. Porter. In Professional Paper 70. Not issued separately.

Yentna district, reconnaissance map; scale, 1: 250,000; by R. W. Porter. Revised edition. In Bulletin 534. Not issued separately.

Mount McKinley region, reconnaissance map; scale, 1: 625,000; by D. L. Reaburn. In Professional Paper 70. Not issued separately.

In preparation.

Kenai Peninsula, reconnaissance map; scale, 1: 250,000; by R. H. Sargent, J. W. Bagley, and others. To be included in Bulletin 587.

Moose Pass and vicinity; scale, 1:62,500; by J. W. Bagley. To be included in Bulletin 587.

Willow Creek district; scale, 1:62,500; by C. E. Giffin.

Broad Pass region, reconnaissance map; scale, 1: 250,000; by J. W. Bagley.

SOUTHWESTERN ALASKA.

REPORTS.

*A reconnaissance in southwestern Alaska, by J. E. Spurr. In Twentieth Annual Report, pt. 7, 1900, pp. 31-264. $1.80.

Gold mine on Unalaska Island, by A. J. Collier. In Bulletin 259, 1905, pp. 102-103.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.

Geology and mineral resources of parts of Alaska Peninsula, by W. W. Atwood. Bulletin 467, 1911, 137 pp.

A geologic reconnaissance of the Iliamna region, Alaska. Bulletin 485, 1912, 138 pp.

Mineral deposits of Kodiak and the neighboring islands, by G. C. Martin. In Bulletin 542, 1913, pp. 125-136.

TOPOGRAPHIC MAPS.

Herendeen Bay and Unga Island region, reconnaissance map; scale, 1: 250,000; by H. M. Eakin. In Bulletin 467. Not issued separately.

Chignik Bay region, reconnaissance map; scale, 1:250,000; by H. M. Eakin. In Bulletin 467. Not issued separately.

Iliamna region, reconnaissance map; scale, 1:250,000; by D. C. Witherspoon and C. E. Giffin. In Bulletin 485. Not issued separately.

*Kuskokwim River and Bristol Bay region; scale, 1:625,000; by W. S. Post. In Twentieth Annual Report, pt. 7. $1.80. Not issued separately.

YUKON BASIN.

*The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin 218, 1903, 71 pp. 15 cents.

Reconnaissance from Circle to Fort Hamlin, by R. W. Stone. In Bulletin 284, 1906, pp. 128-131.

*Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin 345, 1908, pp. 179-186. 45 cents.

*Water-supply investigation in Alaska, 1906-7, by F. F. Henshaw and C. C. Covert. Water-Supply Paper 218, 1908, 156 pp. 25 cents.

*Water supply of the Fairbanks district in 1907, by C. C. Covert. In Bulletin 345, 1908, pp. 198-205. 45 cents.

The Fortymile quadrangle, Yukon-Tanana region, Alaska, by L. M. Prindle. Bulletin 375, 1909, 52 pp.

Water-supply investigations in Yukon-Tanana region, 1907-8 (Fairbanks, Circle, and Rampart districts), by C. C. Covert and C. E. Ellsworth. Water-Supply Paper 228, 1909, 108 pp.

*Water supply of the Yukon-Tanana region, 1907-8, by C. C. Covert and C. E. Ellsworth. In Bulletin 379, 1909, pp. 201-228. 50 cents.

*Gold placers of the Ruby Creek district, by A. G. Maddren. In Bulletin 379, 1909, pp. 229-233. 50 cents.

*Gold placers of the Innoko district, by A. G. Maddren. In Bulletin 379, 1909, pp. 238-266. 50 cents.

The Innoko gold-placer district, Alaska, with accounts of the central Kuskokwim Valley and the Ruby Creek and Gold Hill placers, by A. G. Maddren. Bulletin 410, 1910, 87 pp.

Mineral resources of Nabesna-White River district, by F. H. Moffit and Adolph Knopf, with a section on the Quaternary by S. R. Capps. Bulletin 417, 1910, pp. 64.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 230-245.

Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district, by B. L. Johnson. In Bulletin 442, 1910, pp. 246-250.

Water supply of the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 251-283.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, p. 172.

Water supply of the Yukon-Tanana region, 1910, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, p. 217.

Gold placer mining developments in the Innoko-Iditarod region, by A. G. Maddren. In Bulletin 480, 1911, pp. 236-270.

*Placer mining in the Fortymile and Seventymile river districts, by E. A. Porter. In Bulletin 520, 1912, pp. 211-218. 50 cents.

*Water supply of the Fortymile, Seventymile, and Eagle districts, by E. A. Porter. In Bulletin 520, 1912, pp. 219-239. 50 cents.

*Placer mining in the Fairbanks and Circle districts, by C. E. Ellsworth. In Bulletin 520, 1912, pp. 240-245. 50 cents.

*Water supply of the Fairbanks, Salchaket, and Circle districts, by C. E. Ellsworth. In Bulletin 520, 1912, pp. 246-270. 50 cents.

The Ruby placer district, by A. G. Maddren. In Bulletin 520, 1912, pp. 287-296. 50 cents.

*Gold placers between Woodchopper and Fourth of July creeks, upper Yukon River, by L. M. Prindle and J. B. Mertie, jr. In Bulletin 520, 1912, pp. 201-210. 50 cents.

The Bonnifield region, Alaska, by S. R. Capps. Bulletin 501, 1912, 162 pp.

A geologic reconnaissance of a part of the Rampart quadrangle, Alaska, by H. M. Eakin. Bulletin 535, 1913, 38 pp.

A geologic reconnaissance of the Fairbanks quadrangle, Alaska, by L. M. Prindle, with a detailed description of the Fairbanks district by L. M. Prindle and F. J. Katz and an account of lode mining near Fairbanks by P. S. Smith. Bulletin 525, 1913, 220 pp.

The Koyukuk-Chandalar region, Alaska, by A. G. Maddren. Bulletin 532, 1913, 119 pp.

A geologic reconnaissance of the Circle quadrangle, Alaska, by L. M. Prindle. Bulletin 538, 1913, 82 pp.

Lode mining near Fairbanks, by P. S. Smith. In Bulletin 542, 1913, pp. 137-202.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and R. W. Davenport. In Bulletin 542, 1913, pp. 203-222.

Water supply of the Yukon-Tanana region, by C. E. Ellsworth and R. W. Davenport. In Bulletin 542, 1913, pp. 223-278.

Gold placers of the Ruby district, by H. M. Eakin. In Bulletin 542, 1913, pp. 279-292.

Gold placers of the Innoko-Iditarod region, by H. M. Eakin. In Bulletin 542, 1913, pp. 293-303.

The Chisana placer district, by A. H. Brooks. In Bulletin 592, 1914, pp. —.

Placer mining in the Yukon-Tanana region, by Theodore Chapin. In Bulletin 592, 1914, pp. —.

Lode developments near Fairbanks, by Theodore Chapin. In Bulletin 592, 1914, pp. —.

Placer mining in the Ruby district, by H. M. Eakin. In Bulletin 592, 1914, pp. —.

Mineral resources of the Yukon-Koyukuk region, by H. M. Eakin. In Bulletin 592, 1914, pp. —.

In press.

The Iditarod-Ruby region, Alaska, by H. M. Eakin. Bulletin 578.

Surface water supply of the Yukon-Tanana region, 1907 to 1912, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 342.

TOPOGRAPHIC MAPS.

Circle quadrangle (No. 641); scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. 50 cents each, or $15 for 50. Also in Bulletin 295.

Fairbanks quadrangle (No. 642); scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, R. B. Oliver, and J. W. Bagley. 50 cents each, of $15 for 50. Also in Bulletins *337 (25 cents) and 525.

Fortymile quadrangle (No. 640); scale, 1:250,000; by E. C. Barnard. 10 cents each, or $3 for 50. Also in Bulletin 375.

Rampart quadrangle (No. 643); scale, 1:250,000; by D. C. Witherspoon and R. B. Oliver. 20 cents each, or $6 for 50. Also in Bulletin 337, and part in Bulletin 535.

Fairbanks special (No. 642A); scale, 1:62,500; by T. G. Gerdine and R. H. Sargent. 20 cents each, or $6 for 50. Also in Bulletin 525.

Bonnifield region; scale, 1:250,000; by J. W. Bagley, D. C. Witherspoon, and C. E. Giffin. In Bulletin 501. Not issued separately.

In preparation.

Upper Tanana River and Ladue Creek region; scale, 1:250,000; by D. C. Witherspoon and J. W. Bagley.

Iditarod-Ruby region, reconnaissance map; scale, 1:250,000; by C. G. Anderson, W. S. Post, and others.

Middle Kuskokwim and lower Yukon region; scale, 1:500,000; by C. G. Anderson, W. S. Post, and others.

Yukon-Tanana region; scale, 1:500,000; relief by shading; compiled from maps by U. S. Geological Survey and from other sources.

SEWARD PENINSULA.

REPORTS.

*A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900, by A. H. Brooks, G. B. Richardson, and A. J. Collier. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 180 pp. 50 cents.

*A reconnaissance in the Norton Bay region, Alaska, in 1900, by W. C. Mendenhall. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 38 pp. 50 cents.

*A reconnaissance of the northwestern portion of Seward Peninsula, Alaska, by A. J. Collier. Professional Paper 2, 1902, 70 pp. 30 cents.

The tin deposits of the York region, Alaska, by A. J. Collier. Bulletin 229, 1904, 61 pp.

Recent developments of Alaskan tin deposits, by A. J. Collier. In Bulletin 259, 1905, pp. 120–127.

The Fairhaven gold placers of Seward Peninsula, Alaska, by F. H. Moffit. Bulletin 247, 1905, 85 pp.

Gold mining on Seward Peninsula, by F. H. Moffit. In Bulletin 284, 1906, pp. 132–141. The Kougarok region, by A. H. Brooks. In Bulletin 314, 1907, pp. 164–181.

Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin 314, 1907, pp. 157–163.

The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin 328, 1908, 343 pp.

*Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin 345, 1908, pp. 206–250. 45 cents.

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358, 1908, 72 pp.

*Recent developments in southern Seward Peninsula, by P. S. Smith. In Bulletin 379, 1909, pp. 267–301. 50 cents.

*The Iron Creek region, by P. S. Smith. In Bulletin 379, 1909, pp. 302–354. 50 cents.

*Mining in the Fairhaven precinct, by F. F. Henshaw. In Bulletin 379, 1909, pp. 355–369. 50 cents.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, Alaska, by P. S. Smith. Bulletin 433, 1910, 227 pp.

Mining in Seward Peninsula, by F. F. Henshaw. In Bulletin 442, 1910, pp. 353–371.

A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, by P. S. Smith and H. M. Eakin. Bulletin 449, 1911, 146 pp.

*Notes on mining in Seward Peninsula, by P. S. Smith. In Bulletin 520, 1912, pp. 339–344. 50 cents.

Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit. Bulletin 533, 1913, 140 pp.

*Surface water supply of Seward Peninsula, Alaska, by F. F. Henshaw and G. L. Parker, with a sketch of the geography and geology, by P. S. Smith, and a description of methods of placer mining, by Alfred H. Brooks; including topographic reconnaissance map. Water-Supply Paper 314, 1913, 317 pp. 45 cents.

Placer mining on Seward Peninsula, by Theodore Chapin. In Bulletin 592, 1914, pp. —.

Lode developments on Seward Peninsula, by Theodore Chapin. In Bulletin 592, 1914, pp. —.

TOPOGRAPHIC MAPS.

*Seward Peninsula, compiled from work of D. C. Witherspoon, T. G. Gerdine, and others of the Geological Survey, and all available sources; scale, 1:500,000. In *Water-Supply Paper 314. 45 cents. Not issued separately.

Seward Peninsula, northeastern portion; reconnaissance map (No. 655); scale, 1:250,000; by D. C. Witherspoon and C. E. Hill. 50 cents each, or $30 a hundred. Also in Bulletin 247.

Seward Peninsula, northwestern portion, reconnaissance map (No. 657); scale, 1:250,000; by T. G. Gerdine and D. C. Witherspoon. 50 cents each, or $30 a hundred. Also in Bulletin 328.

Seward Peninsula, southern portion, reconnaissance map (No. 656); scale, 1:250,000; by E. C. Barnard, T. G. Gerdine, and others. 50 cents each, or $30 a hundred. Also in Bulletin 328.

Seward Peninsula, southeastern portion, reconnaissance map (Nos. 655–656); scale, 1:250,000; by E. C. Barnard, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 449. Not issued separately.

Nulato-Norton Bay region; scale, 1:500,000; by P. S. Smith, H. M. Eakin, and others. In Bulletin 449. Not issued separately.

Grand Central quadrangle (No. 646A); scale, 1: 62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents each, or $3 for 50. Also in Bulletin 533.

Nome quadrangle (No. 646B); scale, 1: 62,500; by G. T. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents each, or $3 for 50. Also in Bulletin 533.

Casadepaga quadrangle (No. 646C); scale, 1: 62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder, 10 cents each, or $3 for 50. Also in Bulletin 433.

Solomon quadrangle (No. 646D); scale, 1: 62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents each, or $3 for 50. Also in Bulletin 433.

NORTHERN ALASKA.

REPORTS.

*Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers, by W. C. Mendenhall. Professional Paper 10, 1902, 68 pp. 30 cents.

*A reconnaissance in northern Alaska across the Rocky Mountains, along Koyukuk, John Anaktuvuk, and Colville rivers, and the Arctic coast to Cape Lisburne, in 1901, by F. C. Schrader, with notes by W. J. Peters. Professional Paper 20, 1904, 139 pp. 40 cents.

*Geology and coal resources of the Cape Lisburne region, Alaska, by A. J. Collier. Bulletin 278, 1906, 54 pp. 15 cents.

*Geologic investigations along the Canada-Alaska boundary, by A. G. Maddren. In Bulletin 520, 1912, pp. 297–314. 50 cents.

The Noatak-Kobuk region, by P. S. Smith. Bulletin 536, 1913, 160 pp.

The Koyukuk-Chandalar region, Alaska, by A. G. Maddren. Bulletin 532, 1913, 119 pp.

TOPOGRAPHIC MAPS.

*Fort Yukon to Kotzebue Sound, reconnaissance map; scale, 1:1,200,000; by D. L. Reaburn. In Professional Paper 10. 30 cents. Not issued separately.

*Koyukuk River to mouth of Colville River, including John River; scale, 1:200,000; by W. J. Peters. In *Professional Paper 20. 40 cents. No issued separately.

Koyukuk and Chandalar regions, reconnaissance map; scale, 1: 500,000; by T. G. Gerdine, D. L. Reaburn, D. C. Witherspoon, and A. G. Maddren. In Bulletin 532. Not issued separately.

Noatak-Kobuk region; scale, 1: 500,000; by C. E. Giffin, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 536. Not issued separately.

○